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TREATMENT OF CITRUS PROCESSING WASTES

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Coca-Cola Company
Orlando, Florida

October 1970

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Treatment of Citrus Processing Wastes

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Treatment of Citrus Processing Wastes

by

THE COCA-COLA COMPANY FOODS DIVISION

Orlando, Florida 32802

for the

ENVIRONMENTAL PROTECTION AGENCY
WATER QUALITY OFFICE

Program 12060 10/70
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ABSTRACT

Plant scale studies were performed to determine operational and treatment parameters for citrus processing wastewaters. Part I discusses treatment of concentrated citrus processing wastewaters combined with domestic sewage using a modified activated sludge process; namely, extended aeration. Part II discusses treatment of weak processing wastewaters using a system which functioned as an aerated lagoon. (M)

Extended aeration yielded 94 to 95 percent BOD removal; however, difficulties concerning positive control of the treatment process were encountered. Variations in mixed liquor suspended solids concentrations, sludge volume indices, sludge recirculation rates, and hydraulic loading were considered principal causes adversely affecting the treatment process.

Excess sludge buildup amounted to approximately 0.5 pounds per pound of influent BOD and sludge wastage accounted for the greater portion of overall nutrient removal from the system.

The aerated lagoon process afforded 91 percent BOD removals when daily average hydraulic and organic loadings were controlled at 6.4 mgd and 6,770 pounds, respectively (detention time 7.9 days).

Kinetic studies yielded a BOD removal rate coefficient for citrus processing wastewaters of 1.46 and an average temperature coefficient of 1.05.

Ecological studies indicated that BOD:N:P ratios of the order of 150:5:1 were adequate for supporting the population of organisms required for effective bio-oxidation.

Organic nutrient removal studies using hyacinths indicated a minimum of 5 days' detention would be required to afford substantial nutrient reduction. Significant organic loading reductions (BOD, COD) were also attained by the hyacinth plant system during the 5-day detention period.

It was found that dried hyacinth plants were similar in food value to alfalfa hay and could be used as a supplement in cattle feed.

This report was submitted in fulfillment of Demonstration Grant No. WPRD 38-01-67 between the Federal Water Quality Administration and The Coca-Cola Company, Foods Division.

CONCLUSIONS AND RECOMMENDATIONS

LEESBURG - PART I

1. The extended aeration modification of the activated sludge process is capable of a high degree of secondary treatment for combined citrus processing and municipal wastewaters. Organic removals averaging 94 percent were afforded even though loading levels exceeded design capacity by an average of 52 percent (4,000 pounds) during weekday operation. Mixed liquor suspended solids concentrations varied generally from 3,000 mg/l to greater than 5,000 mg/l. BOD reductions varied generally between 90 and 98 percent. A slight correlation was suggested between higher mixed liquor suspended solids levels and higher BOD removals. This was accomplished despite inexperience of operators and several difficulties enumerated below.
2. The Leesburg plant was designed for a daily biochemical oxygen demand (BOD) loading of 8,000 pounds, and constructed for about \$500,000. Based on long-term data, it afforded an average BOD reduction of 95.6 percent at an average daily loading of 6,810 pounds, and 94.2 percent BOD reduction at an average weekday loading of 12,200 pounds. Underdesign of the clarifiers and inadequate sludge removal facilities significantly deterred continuous optimum daily operations.
3. Principal difficulties with the treatment process involved positive control of following factors:
 - A. Highly variable BOD loads prevented practicable control of mixed liquor suspended solids (MLSS) at design ratio of 10 pounds MLSS per pound of BOD applied;
 - B. High sludge volume indices (SVI) caused by filamentous organisms, *sphaerotilus*, due to high carbohydrate concentrations characteristic of citrus wastewaters;
 - C. Sludge recirculation rates were extremely variable due to erratic wastewater flow patterns; and
 - D. Hydraulic loadings were subject to considerable variation due to erratic citrus wastewater flow patterns.
4. Treatment process control and efficiency would be enhanced significantly by:
 - A. Design Parameters
 1. Equalization of citrus process wastewater loadings; and
 2. Minimization of flow surges by means of a holding pond.

B. Operational Parameters

1. Maintain a MLSS concentration of about 4,500 mg/l or about 14 pounds of MLSS under aeration per pound of influent BOD per day; and
 2. Maintain a sludge recirculation rate of less than 100 percent of plant influent flow.
-
5. Clarification was affected significantly by sludge bulking due to poor SVI control and flow surges. Solids carryover in clarifier effluent was almost a daily occurrence during the height of the citrus processing season.
 6. Based on very rough estimates, some 0.4 to 0.6 pounds of waste sludge solids were provided per pound of influent BOD. This was significantly higher than anticipated for domestic waste alone by extended aeration.
 7. Facilities for disposing of waste sludge were inadequate. Further studies are required to determine most economical improvements. However, the current disposal problems could be minimized by controlling MLSS concentration to about 4,500 mg/l by daily wastage from clarifier at highest practical solids content.
 8. BOD reductions of better than 90 percent were afforded with no supplemental nutrients, despite a relatively high BOD: Nitrogen ratio of about 30:1 in the combined raw wastewater. The addition of supplemental nutrients produced no observable change in BOD removal efficiencies.
 9. Average nitrogen and phosphorous removals of the order of 70 and 90 percent, respectively, were largely accounted for in waste sludge removal from the system. These removals appeared to be independent of MLSS levels. Oxygen transfer levels were not studied.
 10. The oxidation pond was quite effective in compensating for deficiencies in treatment process control. The pond contributed significantly to overall BOD reductions during periods of excessive solids carryover from the clarifiers. On an average the pond achieved 14 percent out of the 94 percent total average BOD removal.
 11. The oxidation pond following the activated sludge process did not provide substantial nitrogen or phosphorous reductions, probably because of the large amount of solids released to the pond over the clarifier weirs.
 12. Clarifiers for service conditions at Leesburg probably should be designed for lower overflow ratio than 750 gpd per square foot. The sludge blanket frequently approached the weir level because of consistently high SVI values. Sludge was sensitive to turbulence during high flow rates and solids carryover resulted. Further studies should be conducted to determine a more suitable design overflow rate.

13. Lower costs probably do not justify the use of vertical turbine pumps recirculating sludge under conditions at Leesburg. Excessive outages were experienced due to stringy solids such as hair which fouled impellers and bearings.

AUBURNDALE - PART II

1. The Auburndale plant was designed for a daily biological oxygen demand (BOD) loading of 18,500 pounds and hydraulic loadings of 30 mgd. Construction costs were approximately \$485,000.
2. The existing facility will not operate as an extended aeration system due to the inadequacy of the sludge collection system. During the period of attempted operation as an extended aeration plant BOD removals averaged 62 percent and mixed liquor suspended solids (MLSS) concentrations averaged only 67 mg/l, despite a wide variety of operating procedures. Therefore, the majority of original grant objectives could not be satisfied.
3. Modification of the existing facility to operate as an extended aeration plant would require:
 - A. Two 200 foot diameter clarifiers;
 - B. A sludge recirculation system; and
 - C. Sludge wastage and treatment facilities.
4. Additional studies during the 1968-1969 citrus processing season indicated that the existing facility would afford adequate BOD removals when operated as an aerated lagoon system. BOD removals of 91 percent were attained at daily average hydraulic and organic (BOD) loadings of 6.4 mgd and 6,770 pounds, respectively.
5. Modification of the existing facility to operate as an aerated lagoon system would entail:
 - A. Approximately 40 additional acres of aeration basins with mechanical aerators;
 - B. Six additional 75 horsepower mechanical aerators; and
 - C. Relocating three aerators from the existing aeration pond to the settling pond.
6. Kinetic studies conducted at Auburndale yielded an average BOD removal rate coefficient ($K_{20}^{\circ C}$ with nutrients) of 1.46 and an average temperature coefficient (θ) of 1.05 (see Appendix 5).

7. Ecological studies confirmed that BOD:N:P ratios of 150:5:1 provided a well balanced system (nutritionwise) that was capable of supporting the variety of organisms required for effective bio-oxidation.

8. The hyacinth study indicated that:

- A. A minimum of five days' detention was required to attain a substantial nutrient removal which was most significant at dissolved oxygen concentrations below 0.5 mg/l.
- B. Hyacinth plants appeared to be comparable to alfalfa hay in composition;
- C. A substantial quantity of wastewater and nutrient was released when the hyacinth plants were squeezed during a drying process (one acre of hyacinths would yield 34,000 gallons of pressed liquor containing 63 mg/l $\text{PO}_4\text{-P}$ and 335 mg/l total-N.
- D. Existing feed mill equipment would require modification in order to incorporate hyacinth plant processing with present feed mill operations;
- E. Microbiota attached to the hyacinth plant roots produced substantial biological and chemical oxygen demand removals (averaging 70 and 47 percent, respectively);
- F. Large scale harvesting operations could be accomplished by means of mechanical devices now available for aquatic vegetation control.

9. Principal difficulties with the treatment process included:

- A. Sludge recirculation could not be accomplished due to an inadequate sludge collection system.
- B. Mixed liquor suspended solids concentrations could not be increased above a maximum monthly average of 103 mg/l due to low sludge concentration of recirculated sludge.
- C. Organic (BOD) and hydraulic loadings increased significantly due to increased processing levels at both The Coca-Cola Company and Adams Packing Company. Statistical studies conducted during the 1966-1967 citrus processing season indicated daily average hydraulic and organic (BOD) loadings of 17.9 mgd and 18,400 pounds, respectively. Studies during the 1968-1969 citrus processing season indicated daily average hydraulic and organic loadings of 30 mgd and 32,500 pounds, respectively. This represents a hydraulic loading increase of 67 percent and an organic loading increase of 77 percent.

10. Inadequacies in plant equipment were found in:
- A. Sludge collection system prevented implementing design concept involving the extended aeration process. Sludge collection area was too large and slopes too gentle (15°) to effectively move sludge to the gravity pickups without mechanical devices. A minimum slope of about 60° is recommended.
 - B. Aerator flotation devices were constructed of fiber glass and were not properly tested by the manufacturer prior to delivery. Apparently 75 horsepower aerators created more stress than the fiber glass floats could withstand causing fatigue cracks and the floats were no longer watertight. This adversely affected the level of aerator submergence.
 - C. High volume, low head lift pumps were used to provide a low cost lift station. The lift pumps were sensitive to small head variations and when all pumps were running simultaneously, discharge rates were somewhat lower than rated capacities.
 - D. A low cost metering system was provided to measure flows between 5 and 50 mgd. However, due to intermittent pumping and subatmospheric pressures when two or more transfer pumps were operating, air frequently became trapped in the transmitter lines. Daily manual venting of the air bleed-off valves was required.
11. Polishing ponds afforded biological oxygen demand (BOD) reductions of approximately 14 percent. Nitrogen concentrations exhibited reductions of 21 percent and phosphate concentrations decreased about 26 percent. Further studies are required to determine whether the nitrogen and phosphorus are soluble forms or are associated with the particulate (suspended solids) matter.
12. Chemical oxygen demand (COD) analyses should be used as an operational control parameter since citrus processing wastewaters inherently contain materials that are toxic, and therefore affect biological oxygen demand (BOD) results. Also the 5-day incubation period required for BOD tests renders the tests useless for operational purposes; whereas, COD tests can be performed in less than one hour's time and operational procedures can be adjusted accordingly.
13. Treatment plant effluent contained about 30 mg/l BOD. However, it could be used for cooling water with little or no additional treatment. At present, pumping costs involved to return effluent water about a half mile to the process plant do not make reuse of treatment plant effluent economically attractive.
14. COD/BOD ratios on the influent stream averaged 1.73. Treatment plant effluent stream COD/BOD ratios averaged 3.34. Influent organic loadings could be estimated by multiplying influent COD loadings by 0.578.

15. Due to the variety of mechanical and operational problems inherent during the first year's operation of a new waste treatment facility, detailed research and plant evaluation studies should be delayed until these difficulties are corrected. At least one year's time should be allowed between completion of construction and beginning of research. This would allow sufficient time to acquaint operators with the treatment process and waste characteristics.

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SECTION 1

INTRODUCTION

Citrus production, processing, and marketing comprises a \$2 billion industry in Florida alone. More than 800,000 acres of the peninsula, extending some 250 miles from north to south, are planted in citrus trees. This area yields about 75 percent of oranges and 80 percent of grapefruit grown in the United States. The total Florida citrus crop for the 1967-1968 season amounted to about 9.0 million tons. For comparison, the United States produced 3.3 million tons of apples, 1.8 million tons of peaches, and 12.1 million tons of potatoes in 1964. Since about one-third of orange acreage had not attained bearing age by the 1966-67 season, and since citrus acreage is constantly expanding, a steady increase in production is anticipated for years to come. Thus, the citrus industry is a very important factor in the economy of Florida.

The majority of Florida citrus is subjected to processing within the State to produce single-strength or concentrated juice for marketing in containers. A survey in 1965 revealed a total of 52 citrus processing plants in the State. These processed about 82 percent of the 1965-1966 crop. It is understandable that operations of such magnitude yield great quantities of waste materials to be dealt with. The industry has made substantial progress in disposing of wastes through recovery of valuable by-products. For example, Florida plants produced 350,000 tons of cattle feed and 48,000 tons of citrus molasses during the 1965-1966 season. Cattle feed production in 1966-1967 amounted to about 573,000 tons. The above mentioned survey indicated, however, that some 130 million gallons per day (mgd) of wastewater, with a 5-day biochemical oxygen demand (BOD) loading of the order of 319,000 pounds per day, were discharged from Florida plants. The Bureau of Sanitary Engineering of the Florida State Board of Health is vigorously proposing treatment of wastewaters from the industry.

There are no standard design parameters for citrus processing plant wastewater treatment. It is generally recognized that plant location is an important factor in determining treatment requirements and planning treatment facilities. For example, The Coca-Cola Company, Foods Division plant at Leesburg, Florida (Figure 1) is located on limited space within the city limits. Prior to 1967, raw wastewater from the plant and primary treated sewage from the nearby Leesburg sewage treatment plant were discharged separately into Lake Griffin (Figure 2). It was determined earlier by the Bureau of Sanitary Engineering, Florida State Board of Health, that secondary treatment of both wastewaters was required for adequate protection of receiving waters. In this particular case, it appeared mutually advantageous for the citrus processing plant and the City to provide treatment facilities for the combined wastewaters. Based on results of laboratory and pilot plant studies covering a two-year period, a treatment plant of the extended aeration type was installed to accommodate the combined wastewaters. This plant was placed in service during 1966-1967 citrus season, and it is the first large-scale facility of its type in the citrus processing industry.

The Coca-Cola Company Foods Division was known as Minute Maid Company during the first part of this study. The latter designation appears on some of the material presented herein to describe results of the study.

SECTION 2

SCOPE AND OBJECTIVES

The general purpose of this study was to investigate treatment of combined citrus processing and municipal wastewaters afforded by the City of Leesburg Wastewater Treatment Plant. More specific objectives included investigation of operating parameters, determination of suitable control limits, and evaluation of plant design criteria. Examination of nitrogen and phosphorous removal in the treatment system was also included in the scope of work.

The primary objective of plant operations at all times is to fulfill an obligation to the public by satisfying the established need for a high degree of treatment of all wastewaters entering the plant. Operational restrictions imposed by this service requirement were seen to place significant limitations on the latitude of investigative work. In view of these restrictions and design capabilities of the plant, it was anticipated that principal operational variables subject to some degree of control for study purposes are mixed liquor suspended solids (MLSS) concentration, phosphorous concentration, and sludge recirculation rate. Investigation of effects of these controlled variables on treatment were prime objectives of the study.

As the plant stands, such variables as dissolved oxygen concentration and nutrient removal are not subject to operational control. Analyses of operating data to relate these variables to other treatment factors were included as study objectives.

SECTION 3

GENERAL DESCRIPTION OF WASTEWATERS

3.01 The Coca-Cola Company Foods Division

Citrus processing plants are operated on a seasonal basis. Some early varieties of fruit mature by September or October, but a succession of others reach maturity later. Inasmuch as oranges may stay on the tree in mature condition for two to five months, considerable control is exercised over the harvesting and processing season, which may extend over eight to ten months.

The principal processing season at the Leesburg plant usually extends from early December into June. Processing is usually discontinued or slackened about midseason between crops of early and late maturing fruit. This lull may extend from a few days to a few weeks, depending upon crop conditions. During the off season, plant facilities are used sporadically for processing lemons and limes and for repacking operations. These off-season activities yield relatively light wastewater loadings.

Wastewater sources in a typical citrus concentrate plant are indicated in Figure 3. The major source of high-strength wastewater is the juice extractor and finisher area, where relatively large volumes of water are used during frequent clean-up periods. Other high-strength wastewaters result from less frequent cleaning of juice storage, evaporator, blend tank, chiller, and packaging areas. All of these wastewaters at the Leesburg plant are screened to remove pulp, peel, seeds, and other suspended solids.

Fruit unloading and preparation operations and barometric condensers yield large volumes of low-strength wastewaters. The former are screened at the Leesburg plant to remove gross solids.

In general, citrus processing wastewaters may be considered as dilute solutions of citrus juice. The pH value is variable. Citric acid content of the juice tends to yield mildly acid values. However, periodic discharges of alkaline agents during clean-up operations result in high pH values. Total solids are comprised largely of sugars, which are readily biodegradable. Other constituents include peptizing agents, which interfere with gravity clarification, and peel oils, which may act as bacteriostatic agents. The wastewaters are usually deficient in nitrogen and/or phosphorous compounds required for optimum treatment by biological processes. Wastewater volume and strength may be subject to considerable fluctuation, depending upon the nature of processing operations.

Total citrus wastewater flow at Leesburg is of the order of 12 mgd. Wastewaters are segregated within the plant into low and high strength fractions. The former, amounting to some 95 percent of the total flow and exhibiting BOD of the order of 30 milligrams per liter (mg/l), is discharged directly to Lake Griffin. The latter are discharged to the City of Leesburg wastewater treatment facilities.

The citrus processing plant at Leesburg operates on a 24-hour per day basis during the principal crop season. It is usually shut down on weekends and holidays. The shutdown period is variable and dependent upon processing requirements.

3.02 City of Leesburg Sewage

The population of Leesburg in 1960 was 11,172. A population of 22,000 is anticipated during the 1980's. The Coca-Cola Company Foods Division citrus processing plant is by far the largest industry in the City.

Existing sewerage serves approximately 80 percent of the population. Average daily sewage flow is of the order of 1.15 mgd. The sewage flows to the treatment facilities in a relatively fresh condition and exhibits an average BOD of the order of 145 mg/l.

Wastewater sources in a typical citrus processing plant are indicated in Figure 1. The major source of high strength wastewater is the juice extractor and filter area where relatively large volumes of water are used during periods of clean-up periods. Other high strength wastewater sources are the large quantities of water sludge, evaporator condensate, and boiler water. All of these wastewaters at the Leesburg plant are treated in a series of tanks and then discharged to the city sewerage system.

From existing wastewater treatment operations and domestic conditions, a high level of low strength wastewater is generated. The former are collected at the Leesburg plant to be treated in the city sewerage system.

In general, citrus processing wastewater may be considered as three sources of effluent. The first is the juice extractor and filter area which produces a high BOD effluent. The second is the evaporator condensate which is a high BOD effluent. The third is the boiler water which is a low BOD effluent. The effluent from the juice extractor and filter area is the most difficult to treat. It contains a high concentration of organic material and is highly variable in composition. The effluent from the evaporator is also highly variable in composition and contains a high concentration of organic material. The effluent from the boiler is the least difficult to treat. It contains a low concentration of organic material and is relatively stable in composition.

Total raw wastewater flow at Leesburg is of the order of 1.5 mgd. Wastewater is generated within the plant in two low and high strength fractions. The former accounts for some 85 percent of the total flow and exhibiting BOD of the order of 10 mg/l. The latter (high) is discharged directly to Lake Griffin. The latter are discharged to the city of Leesburg's wastewater treatment facilities.

SECTION 4

WASTEWATER TREATMENT PLANT

4.01 General Description

The plant is a modification of the activated sludge type designed for extended aeration of unclarified wastewaters with completely mixed recycled sludge. A shallow oxidation pond was provided for further polishing of the effluent prior to ultimate discharge. A schematic flow diagram is presented in Figure 4.

The plant includes elements of an older primary plant provided for City of Leesburg sewage. Additional secondary treatment facilities were constructed on an adjoining site to accommodate combined sewage and citrus processing plant wastewaters. Elements of the above mentioned primary plant are indicated in the upper portion of Figure 4. Certain of these, including the comminutor, degritter parshall flume and wet well still accommodate City sewage alone. The thickener indicated in Figure 4 is actually the old primary plant clarifier, with no modifications. Remaining elements of the primary plant are the two digesters and sludge drying beds indicated in the figure.

Citrus processing wastewaters are delivered to the treatment site by a pumping station located at the citrus plant. Facilities were included at the treatment plant for adding supplemental phosphorus, in the form of phosphoric acid, to the citrus waste. Citrus wastewater, raw sewage and recirculated sludge are blended in a head box, which is the first element of the new treatment facilities. The mixture is apportioned by mud valves in the bottom of the head box to two aeration basins. These are lined earthen basins, and each was provided with two 60 horsepower, mechanical aerators mounted on piers. Aeration basin effluent is combined in common gravity piping and then divided into two suction type clarifiers. Clarified wastewater is recombined in common gravity piping, chlorinated, and discharged to a shallow, earthen pond. Pond effluent is discharged to Lake Griffin (Figure 2).

Provisions were made for wasting sludge from the two clarifiers to the clarifier of the old primary plant, described in Figure 4 as a thickener. It was anticipated that this clarifier and the digesters would be adequate for storage and thickening of sludge prior to further dewatering on the drying beds and/or ultimate disposal by hauling.

4.02 Design Criteria and Characteristics

Plant design criteria are summarized as follows:

	City Sewage	Citrus Processing	Total
Daily Wastewater flow, mgd:			
Average	2.50	0.85	3.35
Maximum	6.25	1.15	7.40
BOD concentration, mg/l	144	706	287
BOD (5-day) load, lbs/day	3,000	5,000	8,000
Recirculated sludge, mgd			3.35
BOD lbs/Mcf			18.3
Extended aeration:			
Mixed liquor suspended solids (MLSS)			
Under aeration, lbs/lb BOD			10
Concentration, mg/l			2,937
Detention, hours			24
Clarifier surface overflow rate, gpd/sq. ft.			730
BOD reduction, %			90+

Design flow and BOD load for city sewage were based on projected conditions for 1975. Actual sewage flow and BOD load averaged 1.15 mgd and 1,400 pounds per day, respectively, in 1964. According to The Coca-Cola Company Foods Division management personnel, above design flow and BOD load for citrus processing waste, which were based on 1964 conditions, should suffice for projected 1975 conditions.

Further details of plant facilities are described in Table 1.

SECTION 5

PLAN OF INVESTIGATION

The general plan of experimentation involved the few variables that were anticipated to be subject to reasonable operational control. These were mixed liquor suspended solids (MLSS), phosphorous concentration, and sludge recirculation rate. It was planned to vary one of these variables at a time in series of tests covering one citrus season. Routine data indicated in Figure 5 would be collected throughout the season. Supplementary routine analyses for nitrogen and phosphorous concentrations in combined wastewater and in clarifier and pond effluents were provided for.

It was proposed to operate under each set experimental conditions for about one month to assure collection of a reasonable average data under equilibrium conditions. Since the duration of the citrus processing season is usually about six months, a rather limited program was planned. This program is summarized as follows:

Condition	Controlled Variable			Test duration, months
	Recirc. Sludge, %	BOD:P Ratio (Combined Waste)	MLSS mg/l	
1	100	100:1	3,000	1
2	100	100:1	4,000	1
3	100	100:1	5,000	1
4	100	As received	Optimum	1
5	100	Midway above	Optimum	1
6	50	Optimum	Optimum	1
			Total	6

Analysis of all data was proposed to afford evaluation of nutrient removal, treatment efficiency, and plant design.

SECTION 6

PLANT OPERATION

6.01 Startup (1966-1967) Citrus Processing Season

Plant construction was far from completion at the beginning of the 1966-1967 citrus processing season, during which it was originally proposed to initiate the investigation. Insistence from City officials resulted in acceptance of citrus wastewaters at the plant early in December, 1966, before any of the secondary treatment units were operable. Citrus wastewaters were routed through one aeration basin, in which the mechanical aerators were inoperable, and remaining facilities were by-passed with a temporary arrangement. Separate operation of the old primary plant was continued for treatment of City sewage in accordance with prior practice. As anticipated, premature acceptance of citrus wastewaters resulted in a variety of significant problems, including objectionable odors, hindered orderly completion of facilities, and multiplied difficulties usually encountered during plant startups.

It was not until February 24, 1967, that plant construction was reasonably complete, and City sewage was diverted to the new facilities. Remainder of the season was devoted largely to training of plant personnel, who were totally inexperienced in operation of secondary treatment facilities; solving usual startup problems with mechanical equipment, instrumentation, etc.; and establishing treatment control, sampling, and analytical procedures to be employed during the investigation.

Reasonable satisfactory operation of the plant was established by mid-April, 1967. Phosphoric acid was added to yield a BOD:P ratio of about 80:1 in raw combined wastewater based on average requirements indicated during pilot plant studies preceding design. Operating data obtained during the last two months of the citrus season are summarized in Table 2. Sludge wastage was insignificant during this period, and the uncontrolled MLSS concentration ranged to values of 6,000 to 7,000 mg/l. Citrus wastewater BOD loadings were significantly higher than the design loading 92 percent of the time, due probably to a bumper crop of fruit and associated problems within the citrus plant. Despite an average weekday BOD loading of 12,200 pounds per day, amounting to an overload of 53 percent of the design loading, BOD reductions were consistently higher than anticipated and averaged 94.2 percent until an aerator reduction gear failure on June 3, 1967. Principal problems of process control involved MLSS concentration and solids carryover from the clarifiers.

6.02 1967-1968 Citrus Processing Season

The detailed program of investigation described earlier was initiated at the outset of the 1967-1968 season. Improvements were made to sampling facilities just prior to the season to assure more dependable data during the studies. These consisted of automatic proportional samplers for raw sewage, raw citrus wastewater, and clarifier effluent, as well as sample pumps for continuous delivery of aerator basin effluent and recirculated sludge. A pH recorder was provided for raw citrus wastewater. These improvements are indicated in Figure 4. Analyses for nitrogen and phosphorous compounds in the wastewaters were initiated in December, 1967.

Average MLSS concentration during the week of November 12, 1967, was about 6,500 mg/l. It was reduced to about 3,000 mg/l by the end of the month and maintained at weekly average values of about 3,100 to 3,750 mg/l until the week of January 14, 1968, in accordance with condition 1 of our program. This was accomplished by wasting some 1,430,000 gallons of sludge at an average rate of 30,500 gpd and ranging to 168,000 gpd.

Sludge was wasted by pumping to the thickener and digesters; settling; drawing off supernatant, which was returned to the sewage wet well; and discharging to a tank truck or sludge drying beds. Since the capacity of the drying beds was no more than about 7,500 gpd, the majority was hauled away to the City's solids disposal area. Limited tests indicated that waste sludge could be thickened to about 3.2 percent solids during the procedure. The thickened sludge dewatered well on the drying beds with little odor, comparable with anaerobically digested sludge.

Reasonable control was maintained over sludge recirculation during the initial study condition. Average recirculation amounted to about 80 percent.

Phosphorous levels in the combined raw wastewaters were considerably higher than anticipated from preliminary laboratory and pilot plant studies preceding design of the plant. BOD:P ratios averaged about 57:1 over the season. Addition of phosphoric acid during the initial study condition resulted in an average BOD:P ratio of about 53:1 rather than 100:1 as indicated in our program. This ratio was maintained, approximately, through March, 1968, to minimize effects of the variable on subsequent studies. Addition of phosphoric acid was discontinued on April 2, 1968, and BOD:P ratios averaged about 70:1 in combined raw wastewaters throughout the remainder of the season.

Operating personnel were requested on January 12, 1968, to maintain a MLSS concentration of about 4,000 mg/l in accordance with condition 2 of our program. This concentration was maintained reasonably well for about two weeks. It was then purposely decreased to about 3,100 mg/l, through wasting sludge, by plant personnel on the advice of Florida State Board of Health personnel in an effort to control a considerable clarifier carryover problem. Thus, the average MLSS concentration for the planned period of study amounted to no more than 3,400 mg/l, or roughly the same as that of the initial period. Sludge recirculation was increased from about 80 percent to about 130 percent by plant personnel in a further effort to control clarifier carryover.

Plant and regulatory agency personnel were quite reluctant to increase MLSS concentration in accordance with our program to 5,000 mg/l despite satisfactory operation at concentrations of more than 6,000 mg/l during the previous season. In view of this and the previous abundant data at higher solids loadings, it was agreed that treatment would be controlled as nearly as possible to design conditions for the remainder of the season. The program involving deliberate variations of treatment factors was abandoned in favor of greater emphasis on collection and analysis of operating data. As it turned out, the season afforded a very wide variety of operating conditions for study. For example, weekly average MLSS concentrations varied from about 2,000 to 4,750 mg/l, and sludge recirculation varied from about 70 to about 185 percent.

BOD loadings were generally within the design value throughout the season, although one weekly average amounted to some 11,300 pounds per day and four others ranged from 8,300 to 9,200 pounds per day. Principal process control problems involved MLSS concentration and clarifier carryover due to sludge bulking. As a result of inexperience, there was a pronounced reluctance on the part of operators to experiment in solving problems. A variety of problems are certain to arise in unique wastewater treatment systems such as that at Leesburg, and operating personnel with adequate education and training in this discipline are requisite to proper end results.

SECTION 7

SAMPLING AND TESTING

7.01 Sampling

Routine sampling of the raw sewage, raw citrus waste, and clarifier effluent was accomplished by means of Chicago Pump Company, "Tru-Test" samplers. Locations are indicated in Figure 4. The sampling systems provided composite samples automatically in direct proportion to flow. Samples were collected over 24-hour periods in 2-gallon polyethylene containers, and were maintained at 40°F. in the refrigerated compartment of the sampler throughout the sampling period.

Since there was no suitable sampling point for collection of combined wastewater samples, these were constructed from composited raw sewage citrus waste samples in proportion to their respective daily flows. A simple nomograph was provided the treatment plant operator to facilitate manual preparation of the samples.

Daily composite samples of the oxidation pond effluent were constructed from periodic grab samples collected over a 24-hour period. These were also maintained at approximately 40°F. in a standard laboratory refrigerator. Aeration basin effluents and recirculated sludge samples were grab samples taken and tested once each 8-hour shift.

7.02 Testing

Routine tests conducted at the plant are indicated in Figure 5.

Semiweekly composite samples of combined wastewater, clarifier effluent, and oxidation pond effluent were analyzed for total nitrogen and phosphorous content. Total nitrogen was determined from analyses for ammonia, organic nitrogen, nitrate, and nitrite.

All testing procedures were in accordance with "Standard Methods for Examination of Water and Wastewater," 12th Edition, APHA, AWWA, WPCF (1965).

Routine sampling and analyses were accomplished by the operating personnel of the City of Leesburg wastewater treatment plant. Training and supervision were provided by Black, Crow and Eidsness, Inc. Nitrogen and phosphorous determinations were made by L & S Laboratory, Winter Haven, Florida. Samples were transported to this laboratory in a refrigerated shipping container by bus. A schedule for handling samples was arranged to permit analysis within a few hours after collection.

SECTION 8

RESULTS

8.01 General Conditions

Data were collected and reviewed for purposes of this investigation from April 19, 1967, through June 30, 1968, covering a total of some 62 weeks. The 1966-1967 citrus processing season was represented by data for April 19 - June 3, 1967. An aerator reduction gear failure on the latter date resulted in bypassing of citrus wastewaters on June 16, 1967. This wastewater stream was returned to the treatment system on July 4, 1968, after the closing of the processing season. The aerator was returned to service on July 6. Citrus wastewaters from this date to early December, 1968, resulted principally from sporadic processing of lemons and limes and for repacking operations. The main 1967-1968 processing season was represented by data collected from December, 1967, through June, 1968.

Typical analytical data pertaining to the wastewaters are shown in Table 3.

8.02 Flow Data

Flows of raw sewage, raw citrus wastewater, and recirculated sludge were measured by Kennison nozzles located as indicated in Figure 4. These were arranged with B-I-F instrumentation to indicate, record and totalize flow of each stream. Clarifier effluent flow was measured by a Parshall flume as shown in Figure 4, also arranged for indicating, recording and totalizing the flow.

Flow data collected during the period of investigation are summarized in Figure 6. Daily sewage flows ranged from 0.723 to 2.02 mgd and averaged 1.106 mgd. Daily citrus wastewater flows during the portion of the 1966-1967 season covered by the investigation ranged to 1.122 mgd and averaged 0.935 mgd. During the 1967-1968 season they ranged to 1.631 mgd and averaged 0.528 mgd. It is seen from Figure 6 that off season flows were considerable.

8.03 Daily BOD Loadings

Daily BOD loadings are summarized in Figure 7. Combined wastewater BOD loading ranged to 31,400 pounds per day and averaged 12,200 during the last few weeks of the 1966-1967 season. During the 1967-1968 season, maximum and average loadings were 22,300 and 6,810 pounds per day, respectively.

Whereas citrus wastewater BOD loading ranged to 29,900 pounds per day and averaged 11,200 during the latter part of the 1966-1967 season, maximum and average loadings during the subsequent season were 20,200 and 5,050 pounds per day, respectively.

Daily BOD loading contributed by City sewage during the entire period of the study averaged 1,315 pounds per day and ranged to 5,840 pounds per day.

Combined wastewater BOD concentrations during the 1967-1968 season are summarized in Figure 8.

8.04 Suspended Solids

Suspended solids concentration in citrus wastewater and sewage averaged 132 and 162 mg/l, respectively, during the period of study.

MLSS concentrations are summarized in Figure 9. Weekly average concentrations ranged between 1,630 and 6,550 mg/l during the period of study.

Clarifier effluent suspended solids concentrations are summarized in Figure 10. Concentrations varied between 0 and 779 mg/l and averaged 78 mg/l during the period of study.

Pond effluent suspended solids varied from 6 to 160 mg/l and averaged 32 mg/l.

8.05 Dissolved Oxygen

Dissolved oxygen concentrations in aeration basins 1 (south) and 2 (north) are summarized in Figures 11 and 12, respectively. Concentration in basin 1 varied from 0.1 to 9.0 mg/l and averaged 2.8 mg/l during the study. That in basin 2 varied from 0.1 to 8.4 mg/l and averaged 2.3 mg/l.

Dissolved oxygen concentrations in the oxidation pond are summarized in Figure 13. These were found to vary considerably with weather conditions, algae blooms, etc., and ranged from 0.2 mg/l to 31 mg/l. The average concentration was 9.3 mg/l.

8.06 pH Values

Citrus wastewater pH values were monitored and recorded continuously by means of a Beckman Model 729 Process Flow Chamber located as indicated in Figure 4. Values ranged from 4.2 to 11.8 and averaged 7.5. A typical weekly pH record is shown in Figure 14. pH values for sewage clarifier effluent and oxidation pond were determined on composited samples. These were quite uniform and averaged about 8.0. Values ranged from 7.0 to 10.1.

8.07 Temperature

Temperatures were comparable in aeration basin and oxidation pond effluents and varied from 17°C. to 31°C., depending upon the ambient temperature. Temperatures for the entire study period are summarized in Figure 15.

8.08 Sludge Recirculation

Data pertaining to sludge recirculation are summarized in Figure 16. Weekly average flows ranged from 42 percent to 184 percent of plant influent flow.

8.09 BOD Removal

Data pertaining to overall BOD removal in the plant are summarized in Figure 17. Despite an average BOD loading some 53 percent in excess of the design loading during the latter part of the 1966-1967 season, the average removal amounted to some 94.2 percent until the aerator failure of June 3, 1967. This failure resulted in decreased removals indicated in Figure 17 from the week of June 4 through the week of July 9, 1967.

Weekly average BOD removals for the 1967-1968 season ranged from 89.0 to 99.0 percent and averaged 95.6 percent.

Despite the aerator failure and subsequent aerator shutdowns to replace reduction gears in all units, average BOD removal for the period of study amounted to 94 percent.

8.10 Suspended Solids Removal

Sparse data pertaining to suspended solids removals were accumulated and are presented in Figure 18. Weekly average removals ranged from 54 percent to 96 percent and averaged 81 percent during the period of study.

8.11 Sludge Volume Index

Sludge volume indices were variable, ranging from a low of 67 to a high of 507 during the period of study. The average SVI value was 263. The data are summarized in Figure 19.

8.12 Waste Sludge

Data pertaining to waste sludge are summarized in Figure 20. Sludge was wasted in insignificant amounts until the week of November 26, 1967, at the start of the 1967-1968 season. Sludge wastage during this season ranged to 165,000 gpd and averaged 20,100 gpd.

8.13 Nitrogen and Phosphorous Analyses

Nitrogen and phosphorous determinations were made to determine: 1) if sufficient quantities of nutrient were available in the influent for efficient bio-oxidation; and 2) removal of these nutrients during treatment. All data in this regard were collected during the 1967-1968 season, and these are summarized in Tables 4 and 5.

SECTION 9

DISCUSSION OF RESULTS

9.01 Flow Data

Figure 6 illustrates that combined wastewater flows were well below the design average of 3.35 mgd. The maximum weekly average flow was 2.38 mgd, and the maximum daily flow of record was 3.24 mgd. The average daily citrus wastewater flow of 0.935 mgd during the latter part of the 1966-1967 season exceeded the design average of 0.85, but the average flow of 0.528 mgd during the more normal 1967-1968 season was significantly less than design conditions.

As indicated in Figure 6, daily citrus wastewater flow were subject to considerable variation. The erratic flow pattern, in conjunction with high and variable BOD loadings, contributed significantly to difficulties in controlling MLSS concentration and sludge recirculation rate.

Daily peak flow of sewage was of the order of 3.0 mgd, although occasional peaks ranged higher. Variable speed drives on the two 3.0 mgd pumps afforded reasonably smooth and predictable flows throughout the day. Typical weekday citrus plant operations during the season resulted in cyclical surging of citrus wastewater flow rates between about 0.5 mgd and 1.25 to 1.40 mgd. The lower rate corresponded to operation of one 350 gpm wet well pump, while the larger rate resulted from operation of the 1,000 gpm pump. During weekend or other plant shutdowns, wastewater flow rate usually varied from 0 to less than 0.5 mgd.

The usual operating procedure resulted in cyclical surging of recirculated sludge between minimum flow rates of about 0 to 0.75 mgd and maxima of 2.0 to 3.5 mgd.

Surging of citrus wastewater and recirculated sludge probably contributed to a significant problem of solids carryover from the clarifiers. Based on an average sludge recirculation rate of the order of 1.0 mgd, an estimated maximum momentary flow rate of 7.9 mgd to the head box (Figure 4) would tend to result in a momentary clarifier surface overflow rate of the order of 1,500 gpd per square foot. The actual effect of such condition on the overflow rate depends, of course, on the flow rate dampening effect afforded by the oxidation ponds.

Indicated measures to minimize difficulties associated with flow surges include:

1. Equalization of citrus wastewater flows by means of a suitable surge pond and variable special pumps,
2. Proper adjustment of sludge recirculation rate controls to minimize surgings,
3. Increased clarifier capacity, and/or,

4. Provisions for better flow rate equalization in aeration basins.

9.02 BOD Loadings and Removals

Daily BOD loadings were highly variable, as indicated in Figures 7 and 8 and in Table 2. These data show that the variability was due mainly to citrus wastewaters. It is seen further that design loadings were exceeded rather extensively. A revealing summary in this regard is as follows:

	Average Daily BOD Loading, lbs.		Percent of Time Design Loading Was Exceeded
	Design	Actual	
City sewage	3,000	1,315	2
Citrus wastewater			
1966-1967 season ⁽¹⁾	5,000	11,200	92
1967-1968 season ⁽²⁾	5,000	5,050	40
Combined wastewater			
1966-1967 season ⁽²⁾	8,000	12,200	61
1967-1968 season ⁽²⁾	8,000	6,810	20

(1) Partial, April 19 - June 9, 1967, only.

(2) December 1, 1967 - June 30, 1968.

Above described loading characteristics subjected the treatment process to severe "shocking," which promoted sludge bulking. This phenomenon contributed largely to frequent difficulties with MLSS concentration control and solids carryover from the clarifiers.

The effect was often well demonstrated early in the week. In these cases the treatment process was upset by resumption of citrus processing, following weekend curtailment. Towards the latter part of the week the sludge evidently became acclimatized to the loading, and evidence of bulking became less pronounced.

Indicated means for minimizing difficulties resulting from the highly variable BOD loads involve equalization of citrus wastewater discharges to the plant throughout the week. Some type of holding tank is the most obvious solution, but potential problem conditions within such a tank receiving raw concentrated citrus wastes should be anticipated. Laboratory studies showed that aeration may cause the raw waste to gel (probably because of high dissolved sugar concentrations) and produce odors, but no aeration may lead to anaerobic conditions with even more severe odor problems.

Despite above described loading characteristics, the treatment system afforded excellent BOD reduction, as attested to by data shown in Figure 17. The oxidation pond played a significant part in overall BOD reduction during period of excessive solids carryover from the clarifiers. For example, contributions by the pond to monthly average overall BOD reductions ranged from 0 to 14.7 percent and averaged 3.0 percent during the 1967-1968 season. During prolonged period of optimum treatment, the pond played a very minor role in BOD reduction. At times BOD values actually increased somewhat through the pond, due evidently to carryover of dead algae cells, etc.

Decreased BOD removals indicated in Figure 17 for weeks of June 4 - July 19, 1967, resulted from an aerator failure. Average BOD reductions amounted to 94.2 and 95.6 percent for the 1966-1967 and the 1967-1968 seasons, respectively.

9.03 Wastewater Suspended Solids and Removal

Suspended solids content of raw sewage and citrus wastewater were of the same general order of magnitude (Table 3). Overall removals described in Figure 18 were affected significantly by copious quantities of algae cells discharged continuously from the oxidation pond. Apparent removals of 80 percent or more occurred 59 percent of the time.

As indicated in Figure 10, suspended solids content of clarifier effluent was variable. Erratic clarification was due to effects of sludge bulking and flow surges mentioned earlier. The data show that the oxidation pond was of significant benefit in compensating for poor clarifier performance.

9.04 Mixed Liquor Suspended Solids (MLSS)

The quantity of MLSS under aeration is of prime concern in activated sludge processes. The design criteria of 10 pounds of MLSS under aeration per pound of daily influent BOD is a generally accepted level for the extended aeration modification of the process. To realize this level with the plant design BOD load of 8,000 pounds per day, would require maintaining a MLSS concentration of 3,000 mg/l in accordance with the design control.

In practice the concentration would be adjusted in accordance with actual BOD loading to maintain the above described 10:1 ratio. The highly variable BOD loads indicated in Figure 7 made such control so difficult that it could not be accomplished reasonably.

Comparison shown in Figure 22 indicates a trend towards a direct relationship between BOD removal and MLSS concentration, particularly when MLSS concentration exceeded 3,000 mg/l. By including Figure 7 in the comparison, it appears that a MLSS concentration of 4,000 to 4,500 resulted in better BOD removals with BOD loads near or exceeding the plant design load. On this basis, it is concluded that some 14 pounds of MLSS under aeration per pound of daily influent BOD is appropriate for conditions at the Leesburg plant. Equalization of citrus wastewater discharges to the plant would facilitate MLSS control.

9.05 Sludge Wastage

Average sludge wastage of 20,100 gpd for the 1967-1968 season was for the purpose of maintaining a MLSS concentration of 3,000 mg/l over all but about two weeks of the season. As shown in Figure 9 such wastage was insufficient to fully satisfy this objective. Conditions were too erratic for collection of reliable data concerning waste sludge solids produced per pound of influent BOD. Based on very rough estimates in regard to average waste sludge solids concentration and solids carryover from the clarifiers, this could have amounted to some 0.4 to 0.6 pounds per pound of BOD during the 1967-1968 season.

Comparisons in Figure 23 indicate that quantity of waste sludge solids produced during citrus processing varies inversely with MLSS concentration. Thus, control of MLSS concentration to a range of the order of 4,500 mg/l as suggested above would tend to minimize the solids handling and disposal problem.

Waste sludge disposal facilities were obviously inadequate for long term operation. The anaerobic digester was too small for the large volumes of sludge produced. The interim solution adopted was periodic hauling of sludge in tank trucks to a land fill for disposal. It was recognized at the outset that improvements would be advisable as soon as problems peculiar to the unique treatment system were clearly defined and evaluated.

9.06 Sludge Recirculation and Sludge Volume Index (SVI)

Sludge recirculation rate must be varied directly as SVI in controlling MLSS to a fixed level. The relationships are illustrated by comparison of data for weeks of November 26, 1967 through March 31, 1968 in Figure 24. MLSS was controlled within a relatively narrow range during most of this period, while sludge recirculation rate and SVI gradually increased.

SVI is dependent to a large extent on factors associated with the particular wastewater. Citrus wastewaters contain large amounts of carbohydrates. Such compounds are notorious for promoting growth of filamentous organisms, such as *sphaerotilus*, during treatment by activated sludge processes. These organisms yield light, bulky sludges that do not settle well and thus promote relatively high sludge volume indices. In view of the relationship between SVI and recirculation rate described above, citrus wastewaters may be expected to require higher than usual recirculation rates during activated sludge treatment. These factors are believed largely responsible for solids carryover from the clarifiers illustrated in Figure 10.

Comparisons in Figure 25 yield some evidence that SVI varies inversely with MLSS concentration. Thus, positive control of MLSS concentration within the above suggested range of 4,000 to 4,500 mg/l could benefit clarification. Comparisons in Figure 26 afford evidence that bulking and solids carryover from the clarifiers might be minimized by positive control of sludge recirculation rate to an absolute minimum. In general, lower sludge volume indices accompanied sludge recirculation rates of less than 100 percent of influent flow.

Equalization of flows and BOD loading would facilitate better control of MLSS concentration, sludge recirculation and SVI.

9.07 Dissolved Oxygen Levels

Inspection of Figure 21 shows that dissolved oxygen levels were generally higher in aeration basin No. 1 (south) than in No. 2 (north). From the week of September 24, 1967, through the week of March 31, 1968, dissolved oxygen concentrations were consistently higher in No. 1. This was accounted for by short circuiting in the head box (Figure 4). Due to the arrangement of Kennison nozzles and the two mud valves serving the basins, basin No. 2 received a disproportionate amount of recirculated sludge. This condition was alleviated by baffling late in March, 1968.

Comparison of Figures 6, 7 and 21 shows that dissolved oxygen concentration in the aeration basins varied inversely with flow and BOD load, as would be expected.

From Figures 10 and 13, it is seen that dissolved oxygen concentration in the oxidation pond appeared to be affected in varying degrees by solids carryover from the clarifiers. Weather conditions and algae blooms were probably of more overall consequence.

9.08 pH Value and Temperature

Despite wide variations in citrus wastewater pH value, as indicated by Figure 14, average pH value of this stream was about 7.5. Buffering capacities of City sewage and mixed liquor were sufficient to yield relatively uniform pH values of the order of 7.5 to 8.0 in the aeration basins.

Although citrus wastewaters were quite warm, temperature of mixed liquor was relatively uniform and followed seasonal patterns.

9.09 Nutrient Removal

The treatment would be expected to yield a final effluent containing little ammonia and organic nitrogen. Nitrate concentration would be expected to increase during treatment. A review of Table 5 shows that such expected results were obtained. Comparison of data in Table 5 for the period of January 17 through May 24, 1968, shows a direct relationship between clarifier effluent suspended solids (bulking) and organic nitrogen in the effluent. It is indicated that the effect of bulking extended through the oxidation pond, where there was a substantial increase in ammonia nitrogen as well as in organic nitrogen.

It is seen in Table 4 that average nitrogen removal through the clarifiers amounted to about 69 percent. There was an indicated additional removal of about 7 percent in the oxidation pond. This is not regarded to be of particular significance, in view of the variability in analytical results.

From Table 4, average phosphorous removal amounted to about 53 percent, and the oxidation pond afforded no additional removal. Average removals through the clarifiers and pond during the period of phosphoric acid addition were 70 and 61 percent, respectively, as compared to 34 and 31 percent after phosphoric acid addition was discontinued. During these respective periods BOD:phosphorous ratios were 53:1 and 70:1.

Since an average daily volume of waste sludge amounting to some 20,100 gallons was removed from the system during the 1967-1968 season an attempt was made to determine the effect on overall removals reported in Table 4. A very limited amount of analytical data was obtained on the sludge. These data indicated that nutrients were removed largely in the waste sludge. Although the data pertaining to nitrogen were rather inconsistent, they show that practically all nitrogen removal was accounted for in the sludge. It was indicated that phosphorus removed in waste sludge amounted to about 94 percent of the overall removal reported in Table 4.

It is generally accepted that BOD:nitrogen ratios of the order of 15:1 to 20:1 and BOD:phosphorus ratios of the order of 80:1 to 100:1 are required for optimum biological treatment of wastewaters. Extensive analytical data collected during laboratory and pilot plant studies preceding plant design indicated that raw combined wastewaters would contain ample nitrogen, but that they would be deficient in phosphorus. Data in Table 4 indicate opposite conditions in regard to raw wastewater nutrient levels. Although some consideration might be given to feeding of a nitrogen compound rather than phosphoric acid, excellent BOD reductions were obtained despite the indicated nitrogen deficiency.

9.10 Plant Equipment

Principal inadequacies in plant equipment were found to deal with waste sludge disposal, sludge recirculation pumps, clarifiers, and citrus wastewater flow control.

Inadequacies in waste sludge disposal facilities were mentioned above under "Sludge Wastage." Improvements to be considered might include digestion facilities, either aerobic or anaerobic. However, observed dewatering characteristics of undigested waste sludge appeared good. Further studies might indicate economic advantages for improved thickening facilities for undigested sludge to be used in conjunction with vacuum filtration, centrifugal filtration, or increased drying bed capacity. In any case, operating procedures should be improved to include daily wastage of sludge from clarifiers at highest practical solids content.

It was assured by the manufacturer that vertical turbine pumps would afford satisfactory service for anticipated recirculated sludge. With this assurance, such pumps were selected as an economic measure. Excessive outages were experienced as a result of solids characteristics. Undegraded gross solids were found to foul impellers and bearings. Stringy solids such as hair were particularly troublesome in fouling bearings. It is possible that such difficulties could have been minimized by different bearing materials, such as Teflon.

As mentioned previously, flow surges and bulking of sludge resulted in clarification problems. It was apparent that clarification of the high SVI solids characteristic of citrus wastewaters was quite sensitive to turbulence in the clarifiers. High sludge levels prevailed because of the relatively high sludge volume indices. Under such conditions, cross members and other obstructions in the upper portion of the clarifiers contributed to intolerable velocities, particularly at high flow rates, that caused solids to carry over the wiers. Further studies are required to determine a more suitable design overflow rate. Apparently this rate should be substantially less than the design value of 750 gpd per square foot that was employed, although the latter is considered conservative in usual design practice.

As mentioned previously, equalization facilities for citrus wastewaters would afford better control of such variables as MLSS and sludge recirculation rate. Clarification would benefit as a result of improved sludge volume indices and reduction of flow surges.

9.11 Cost of Treatment

For the 1969-70 season the Leesburg Plant processed ... 6,785,000 boxes of fruit and sent 996,000# BOD to the city treatment plant for treatment.

Cost of Treatment	\$9,442.00
Waste Load - #BOD	996,000#
Fruit Processed - Boxes	6.785X10 ⁶
Treatment Cost	
\$/#BOD	\$.0095
\$/Box Fruit	\$.0014

SECTION 10

ECOLOGICAL STUDY

10.01 GENERAL

A detailed ecological survey of the Leesburg wastewater treatment facility was made by Dr. James B. Lackey to characterize biota associated with the treatment process. At the time of the facility to characterize biota associated with the treatment process. At the time of the survey the plant was operating effectively and BOD removal averaged better than 95 percent.

10.02 LEESBURG EXTENDED AERATION SYSTEM

Over a period of several years, intermittent observation of the Leesburg situation exhibited that: (1) a high degree of BOD removal had not been achieved; (2) combinations of citrus waste and domestic sewage produced a varied biota in a pilot plant trickling filter experimentally operated; (3) large quantities of citrus waste solids entered the canal which extended out to Lake Griffin; (4) a great deal of gassing occurred in this canal and that sludge banks had formed therein; (5) in this canal containing the combined waste, a large and heterogeneous population of algae and protozoa was found.

On March 10, 1969, microbiota at the Leesburg plant were studied. A qualitative examination of the sludge flocs in the aeration chambers, of the growths on the clarifier walls, of the rising sludge in the polishing pond, and of the polishing pond (final) effluent was made and the results are exhibited in Table 6. Mixed liquor in the aeration basins was a light brown mixture of debris, bacteria, and animals. No photosynthetic organisms were present in the mixture. Bacteria were predominant and typical of biota developed on a complex organic substrate, actively carrying on conversion to a simple substrate. Free living bacteria were scarce; however, bacterial masses, typical colonies of *Zooglea*, unidentified filamentous forms and *Sphaerotilus* were present in vast quantities. As shown in column 1 of Table 6, the remaining organisms (except for *Acineta*) were consumers of bacteria. They totaled 7,575 per ml and 7,067 of these were *Vorticella*, *Opercularia*, and *Epistylis*. With such a predator population, the bacteria should be kept at a high reproductive working level.

The floc in the clarifiers appeared to have excellent settling properties, and the supernatant (clarifier effluent) was free of suspended solids. Growth on the clarifier walls was composed of the same organisms found in the aeration basins with an additional five photosynthetic genera. Three were blue-green algae with *Euglena gracilis* which is indicative of simpler organic compounds available for uptake. *Navicula*, the dominant one of these five is probably more dependent upon nitrogen and phosphorus.

The polishing pond was green in color, with a visibility of about two feet. Its effluent was of excellent clarity and free of odor. Its biota contained 11 photosynthetic species to 9 colorless species. However, green algae were predominant and a small

filamentous green (unrecognized) was the most abundant. Three *Volvocales* and one *Euglena* indicated a good uptake of soluble organic matter, but the remaining seven species are known to utilize nitrogen and phosphorus. The numbers present indicate considerable uptake.

The algal population should insure good oxygenation despite an indication that substantial quantities of organic matter remain in the clarifier effluent and exert a high oxygen demand. This is supported by the fact that *Trepomonas*, *Hexamitus*, and *Gastronauta*, which tolerate low oxygen tensions, were found in the sludge which floats up from the bottom of the oxidation pond.

The Leesburg plant was operating successfully and had a balanced biota; however, the balance between efficient and inefficient performance is delicate. A sudden change such as a large slug of peel oil or alkali could adversely affect the treatment process.

Organisms in the oxidation pond effluent that are contributed to Lake Griffin are acceptable species. Together with the biota presently existing in the lake, they should be able to mineralize the increased fertilization. Since the biota concerned is a balanced one, and of the type desirable in lake water of good quality, it is beneficial to the lake.

TABLES

TABLE 1
CHARACTERISTICS OF TREATMENT PLANT FACILITIES

Sewage Facilities:

Comminutor

Capacity, mgd 6.0

Degritter

Type Air

Capacity, mgd 6.0

Wet well pumps

Number 2

Drive Variable speed

Capacity (each), gpm 2,100

Head, ft. 40

Citrus Wastewater Facilities

Wet well pumps (at citrus plant)

Low service

Number 2

Type Non clog wet pit

Capacity (each), gpm 350

Head, ft. 15

High service

Number 1

Type Non clog wet pit

Capacity, gpm 1,000

Head, ft. 36

TABLE 1
(continued)

CHARACTERISTICS OF TREATMENT PLANT FACILITIES

Phosphoric acid feeding equipment	
Storage tank capacity, gal	1,500
Feed pumps	
Number	2
Type	Wallace & Tiernan A747 single head metering
Combined Wastewater Facilities	
Aeration basins	
Number	2
Capacity (total), MMG	3.26
Detention (design), hours	24
Aerators	
Number	4
Type	Mechanical
Horsepower (each)	60
Clarifiers	
Number	2
Type	Suction (Eimco)
Diameter, ft.	55
Detention (design), hours	2.5
Surface overflow rate (design) gpd/sq. ft.	750
Weir overflow rate (design), gpd/lin. ft.	10,000
Sludge recirculation pumps	
Number	2
Type	Vertical turbine

TABLE 1
(continued)

CHARACTERISTICS OF TREATMENT PLANT FACILITIES

Sludge recirculation pumps - (continued)

Capacity (each), gpm	1,400
Head, ft.	25

Waste sludge pumps

Number	2
Type	Non clog wet pit
Capacity (each), gpm	150
Head, ft.	25

Chlorination equipment

Chlorine storage	1-ton containers
Feeder capacity, lbs/24 hours	1,000

Oxidation Pond

Depth (approx.), ft.	3
Area (approx.), acres	5
Capacity (approx.), MMG	4.40
Detention (design), hours	31.5

Thickener

Diameter, ft.	50
Capacity, gallons	157,000

Digesters

Large

Type	Floating cover-unheated
Diameter, ft.	50
Capacity, gallons	150,000

TABLE 1
(continued)

CHARACTERISTICS OF TREATMENT PLANT FACILITIES

Digesters - (continued)

Small

Type

Fixed cover-unheated

Diameter, ft.

25.5

Capacity, gallons

76,000

Sludge drying beds

Area, sq. ft.

8,590

TABLE 2

CITY OF LEESBURG SEWAGE TREATMENT PLANT
OPERATING DATA DURING 1964-67 CITRUS PROCESSING SEASON

MINUTE MAID COMPANY - LEESBURG, FLORIDA

Federal Water Pollution Control Administration

Grant No. WPRD 18-61-47

Date	Day of Week	Inflow Flow, M. Gal.			S i d e			Suspended Solids, mg/l			5-Day BOD, mg/l			BOD Removal %			Direct-to-Ocean, mg/l			3-Day BOD Load, lb./day			Remarks
		Minute	Hour	Total	Recirculated (%)	Waste (%)	Percent	Pond Effluent	Clarifier Effluent	Mixed Effluent	City	City	City	5	10	15	Mixed Effluent	Clarifier Effluent	City	City	City	Total	
1962																							
April																							
19	W	900	1,020	1,920	660	14.4		1,720			6,000	164								29,970	1,400	31,370	
20	T	943	1,010	1,953	925	46.9		2,980			1,200	174								9,410	1,470	10,880	
21	F	919	1,013	1,932	928	48.0		3,440			1,117	47								9,720	462	10,180	
22	S	1,045	1,026	2,071	952	61.1		3,400			1,117	47											
23	S	922	1,009	1,931	770	77.7		3,110			416	309											
24	S	942	1,009	1,951	770	77.7		3,110			416	309											
25	T	980	1,087	2,067	994	48.1		3,520			1,467	380								11,990	1,100	13,090	
26	W	929	1,140	2,069	1,139	54.3	1 hour to 3,140				2,550	285								19,740	2,760	22,500	
27	T	981	1,051	2,032	1,267	62.4	thickener	3,810			884	96								7,230	841	8,070	
28	F	1,037	1,018	2,055	1,382	67.8	1,500 gal	3,810												8,430	390	8,820	
29	S	1,199	1,048	2,247	1,575	70.5		4,730			1,213	79								11,170	993	12,160	
30	S	914	987	1,901	1,597	83.7		4,730			1,450	68								12,570	514	13,080	
May																							
1	M	48	601	649	1,034	116		6,160			299	195								120	1,370	1,490	
2	T	685	982	1,667	866	52.5		4,120			2,400	110								13,700	1,485	15,180	
3	F	1,026	956	1,982	1,077	54.3	3,000 gal	5,100			1,482	92								16,410	1,180	17,590	
4	S	983	972	1,955	1,310	67.0		5,110			1,482	92								9,980	749	10,730	
5	F	1,015	967	1,982	1,256	63.4		5,170			1,750	70								14,331	967	15,298	
6	S	1,021	978	1,999	1,321	66.1		5,170			1,750	70								10,150	956	11,100	
7	T	88	913	1,001	1,348	135		5,730			2,150	70								1,580	532	2,110	
8	M	101	1,023	1,124	1,362	119		5,710			1,113	179								359	682	991	
9	T	1,001	1,023	1,124	1,362	119		5,710			1,113	179								10,260	1,400	11,660	(6)
10	W	1,006	965	1,971	1,310	66.4	1,075 gal	5,710			771	91								7,000	731	7,730	(7)
11	T	1,006	965	1,971	1,310	66.4		5,710			771	91								9,860	1,060	10,920	
12	F	692	1,024	1,716	1,436	86.4		5,690			1,023	124								8,780	709	9,480	
13	S	1,082	1,024	2,106	1,426	67.8		5,820			975	83								19	96.5		
14	S	991	978	1,969	1,545	78.5		5,820			975	83								1,580	532	2,110	
15	M	48	886	934	1,239	135		6,160			1,167	110								35	64	99	
16	T	1,071	1,116	2,187	1,194	54.6		5,710			1,167	110								1,580	532	2,110	
17	F	1,042	1,194	2,236	1,310	58.6		5,710			1,167	110								1,580	532	2,110	
18	S	1,042	1,194	2,236	1,310	58.6		5,710			1,167	110								1,580	532	2,110	
19	F	1,029	976	2,005	1,181	58.9		5,990			1,167	110								1,580	532	2,110	
20	S	994	950	1,944	1,079	54.0		6,160			1,167	110								1,580	532	2,110	
21	S	933	928	1,861	1,079	54.0		6,160			1,167	110								1,580	532	2,110	
22	M	155	970	1,025	985	96.1		6,160			1,167	110								1,580	532	2,110	
23	T	722	1,042	1,764	1,222	69.3	3,000 gal	5,710			1,167	110								1,580	532	2,110	
24	F	1,042	1,194	2,236	1,310	58.6		5,710			1,167	110								1,580	532	2,110	
25	T	864	960	1,824	1,042	57.2		5,920			1,423	225								1,580	532	2,110	
26	F	962	982	1,944	1,027	52.6		5,880			1,423	225								1,580	532	2,110	
27	S	680	959	1,639	1,420	77.7		6,220			1,423	225								1,580	532	2,110	
28	S	681	961	1,642	1,556	85.4		6,220			1,423	225								1,580	532	2,110	
29	M	82	990	972	1,223	126		7,020			1,423	225								1,580	532	2,110	
30	T	1,042	1,194	2,236	1,310	58.6		6,220			1,423	225								1,580	532	2,110	
31	W	1,042	1,194	2,236	1,310	58.6		6,220			1,423	225								1,580	532	2,110	
June																							
1	T	630	930	1,560	1,454	82.6		6,500			1,423	269								9,910	2,080	11,990	
2	F	985	905	1,890	1,455	77.9		6,500			1,423	269								9,910	2,080	11,990	
3	S	1,011	929	1,940	1,483	76.4		6,500			1,423	269								9,910	2,080	11,990	
4	S	1,011	929	1,940	1,483	76.4		6,500			1,423	269								9,910	2,080	11,990	
5	M	948	960	1,908	1,420	74.4		5,240			1,800	139								10,950	348	11,290	(8)
6	T	948	960	1,908	1,420	74.4		5,240			1,800	139								10,950	348	11,290	
7	W	1,004	949	1,953	1,246	63.8		5,700			2,750	183								3,720	855	4,570	
8	T	1,018	949	1,967	1,352	70.4		5,620			2,750	183								3,720	855	4,570	
9	F	1,041	911	1,952	1,407	72.1		5,760			2,750	183								3,720	855	4,570	
10	S	1,122	909	2,031	1,356	66.3		5,600			2,750	183								3,720	855	4,570	
11	T	1,122	909	2,031	1,356	66.3		5,600			2,750	183								3,720	855	4,570	
12	M	897	770	1,667	1,404	84.1		5,600			2,750	183								3,720	855	4,570	
13	T	488	953	1,441	1,325	92.6		5,760			2,750	183								3,720	855	4,570	
14	W	1,075	902	1,977	1,511	83.6		5,760			2,750	183								3,720	855	4,570	

NOTE: All samples were grab samples excepting Minute Maid raw waste, which were 24-hour composites of hourly grabs.

(1) Total flow is sum of Minute Maid and City waste flows as measured by Krensen meter.

(2) Not including waste sludge returned head box from waste sludge pump.

(3) Sludge wasted continuously to head box from waste sludge pump to control clarifier carryover. Values in column represent waste sludge (gallons) pumped directly to digester.

(4) Waste suspended solids and BOD are high, sampling was accomplished during periodic carryover problem.

(5) Calculated

(6) 6-day BOD value

(7) 4-day BOD value

(8) Reduction gear, wet aerator No. 3 basin breaks at 11:45 P.M.

TABLE 3
CHARACTERISTICS OF TYPICAL WASTEWATERS

Constituent	City Sewage	Citrus Wastewater		Combined Wastewater	
		1966-67 Season	1967-68 Season	1966-67 Season	1967-68 Season
BOD (5-day), mg/l	139	1470	1044	782	409
Solids:					
Suspended, mg/l	149	144	196	148	183
Settleable, ml/l	6	60	20	21	8
Nutrients, mg/l:					
Nitrogen (total)					17.2
Phosphorus (total)					7.9
BOD:Nutrient Ratio:					
Nitrogen					31:1
Phosphorus					57:1
pH value	8.2	8.4 ⁽¹⁾	8.0 ⁽¹⁾	8.0	7.9

(1) Subject to extreme variation.

TABLE 4
NUTRIENT LEVELS AND REMOVALS

BOD:Nutrient Ratio							
Sample Date	Raw Combined		Dosed ⁽¹⁾	Removal, %			
	Wastewater		Wastewater	Nitrogen		Phosphorus ⁽³⁾	
	Nitrogen	Phosphorus	Phosphorus	Clarifier	Pond	Clarifier	Pond
1967							
Dec 14	39:1	26:1	97:1	89	79	63	61
16	31	17	79	92	90	66	49
20	33	66	45	92	91	40	44
23	33	60	44	95	94	39	48
27	16	29	23	94	93	71	62
29	39	78	55	92	91	40	59
1968							
Jan 3	33	53	46	95	93	84	70
5	34	62	53	93	92	86	75
10	25	30	27	94	94	83	89
12	30	63	52	94	95	85	79
17	37	75	61	85	93	84	86
19	24	71	55	70	95	41	75
24	42	77	60	-	86	-	68
26	33	63	51	72	85	76	60
31	42	88	71	12	90	41	75
Feb 2	43	80	66	60	87	71	74
7	46	88	72	69	76	75	65
12	-	-	-	67	82	45	72
14	27	49	40	64	77	63	65
16	30	61	51	87	85	67	65
22	36	56	46	-	69	7	54
24	30	69	53	13	74	4	36
28	28	65	47	22	66	39	37

TABLE 4
(continued)

NUTRIENT LEVELS AND REMOVALS

Sample Date		BOD:Nutrient Ratio			Removal, %			
		Raw Combined		Dosed ⁽¹⁾ Wastewater Phosphorus	Nitrogen		Phosphorus ⁽³⁾	
		Wastewater			Clarifier	Pond	Clarifier	Pond
		Nitrogen	Phosphorus					
1968 - (continued)								
Mar	1	30	84	65	44	74	-	41
	6	25	61	54	90	79	85	48
	8	14	25	24	86	75	83	58
	13	14	47	41	13	50	37	34
Apr	3	29	75	-	-	-	-	21
	5	33	89	-	82	39	21	26
	10	-	-	-	20	61	20	40
	12	31	53	-	71	32	-	6
	17	23	49	-	64	49	41	41
	26	33	65	-	60	57	25	14
May	3	26	62	-	70	55	80	54
	17	31	76	-	76	52	34	34
	24	40	94	-	60	51	15	39
Average		31:1	57:1 ⁽²⁾	53:1	69	76	53	53

(1) Raw combined wastewater dosed with phosphoric acid through April 2, 1968.

(2) Average through March 13, 1968 only, 59:1.

(3) Based on dosed wastewater from December 14, 1967 - May 24, 1968.

TABLE 5
ANALYSES FOR NITROGEN AND PHOSPHORUS
(Results in mg/l)

Sample Date	Raw Combined Wastewater					Clarifier Effluent					Oxidation Pond Effluent				
	Nitrogen, as N					Nitrogen, as N					Nitrogen, as N				
	NH ₃	Org.	NO ₃	Phos.(1)	BOD 5-day	NH ₃	Org.	NO ₃	Phos.(1)	BOD 5-day	NH ₃	Org.	NO ₃	Phos.(1)	BOD 5-day
1967															
Dec 14	6.60	6.70	0	6.2	192	0.03	0.99	0.4	6.2	22	0.12	1.07	1.6	6.4	17
Dec 16	7.80	7.70	0	8.8	136	0.05	1.00	0.2	6.5	-	0.07	0.91	0.6	9.6	-
Dec 20	7.30	7.00	0	21.7	184	0.06	0.92	0.2	18.7	13	0.03	1.02	0.2	17.5	9
Dec 22	7.20	6.80	0	23.9	228	0.02	0.50	0.2	19.6	14	0.01	0.58	0.2	17.0	10
Dec 27	10.00	6.80	0.2	28.2	160	0.09	0.58	0.4	10.5	8	0.14	0.88	0.2	13.5	7
Dec 29	8.40	6.20	0	22.6	132	0.03	0.76	0.4	19.0	11	0.08	0.77	0.4	13.3	8
1968															
Jan 3	9.50	8.60	0	34.6	256	0.04	0.65	0.2	6.0	6	0.03	0.97	0.2	11.8	8
Jan 5	7.10	8.80	0.2	27.4	144	0.02	0.83	0.2	4.3	7	0.04	0.97	0.2	8.0	9
Jan 10	7.70	11.00	0	47.3	232	0.02	0.81	0.2	8.9	5	0.05	0.88	0.2	5.7	6
Jan 12	9.20	10.60	0	28.3	132	0.03	0.91	0.2	5.1	9	0.04	0.82	0.2	7.5	7
Jan 17	9.40	7.20	0	25.3	188	0.06	2.04	0.4	4.8	13	0.10	0.84	0.2	4.3	7
Jan 19	4.00	9.10	7.6	21.5	-	0.06	5.70	0.4	16.3	178	0.06	1.07	0	7.0	8
Jan 24	6.90	6.70	0	23.0	268	0.20	24.80	2.0	39.5	461	0.04	1.45	0.4	9.4	11
Jan 26	8.40	5.60	0	22.7	168	0.04	2.46	0.4	6.7	35	0.06	1.67	0.4	11.3	9
Jan 31	6.96	7.92	0.8	22.8	276	0.15	12.65	1.0	16.7	232	0.06	1.09	0.4	7.0	12
Feb 2	9.29	5.41	0	24.4	224	0.06	4.18	0.6	8.7	71	0.06	1.42	0.4	7.6	9
Feb 7	6.80	8.00	0	23.4	241	0.13	3.59	0.8	7.3	63	0.50	2.30	0.8	10.1	14
Feb 12	8.42	7.23	0	26.7	230	0.06	4.26	0.8	17.7	24	0.64	1.72	0.4	8.9	-
Feb 14	8.80	6.15	1.0	26.6	210	0.07	4.37	1.3	11.9	87	0.30	1.85	1.6	11.2	13
Feb 16	8.88	8.50	0.6	27.2	244	0.03	0.93	1.4	10.6	21	0.29	1.11	1.3	11.2	9
Feb 22	7.51	6.09	0	27.2	171	0.19	19.16	0.8	31.1	376	0.91	1.68	1.6	15.5	20
Feb 24	9.50	5.12	0.6	20.5	119	0.10	11.62	1.5	25.6	398	0.78	1.60	1.6	17.2	15
Feb 28	7.56	5.76	0.6	18.3	175	0.20	9.03	1.6	15.2	251	1.39	2.15	1.2	15.7	12
Mar 1	9.21	9.79	1.2	21.8	220	0.18	11.17	0	30.5	164	1.79	1.99	1.4	16.6	15
Mar 6	11.05	13.75	1.2	33.0	313	0.07	0.81	1.6	5.5	32	1.84	2.13	1.4	19.2	15
Mar 8	14.60	7.80	1.0	40.0	328	0.02	1.36	1.8	7.0	11	2.18	1.98	1.6	17.5	20
Mar 13	11.00	4.00	1.6	15.0	197	0.40	12.40	1.6	10.7	8	5.30	1.40	1.6	11.2	25
Apr 3	7.60	6.80	0	17.8	153	0.16	6.55	24.8	21.1	228	1.76	2.02	23.8	14.1	29
Apr 5	7.55	12.45	0	22.5	224	0.04	1.16	1.6	17.8	4	1.31	1.49	9.2	16.7	12
Apr 10	10.95	9.05	1.2	35.3	-	0.29	1.43	15.2	28.2	24	1.39	3.17	3.6	21.0	64
Apr 12	6.71	5.69	0.8	24.1	-	0.05	2.55	1.2	31.4	30	1.92	3.36	3.6	22.6	31
Apr 17	9.75	9.45	0.5	28.1	256	1.13	3.15	2.8	16.6	26	5.45	2.55	2.0	16.5	4
Apr 26	10.24	6.88	0	26.5	275	0.20	4.96	1.6	20.0	78	0.32	6.08	1.0	22.7	8
May 3	9.44	10.24	0	25.0	279	0.11	4.57	1.2	5.0	33	1.33	6.04	1.4	11.5	58
May 17	6.40	9.00	0.4	19.7	148	0.50	2.45	0.9	13.0	22	0.70	5.90	0.9	13.0	33
May 24	6.90	9.10	0.2	21.3	144	0.17	5.00	1.3	18.2	45	0.16	6.70	1.1	13.0	37

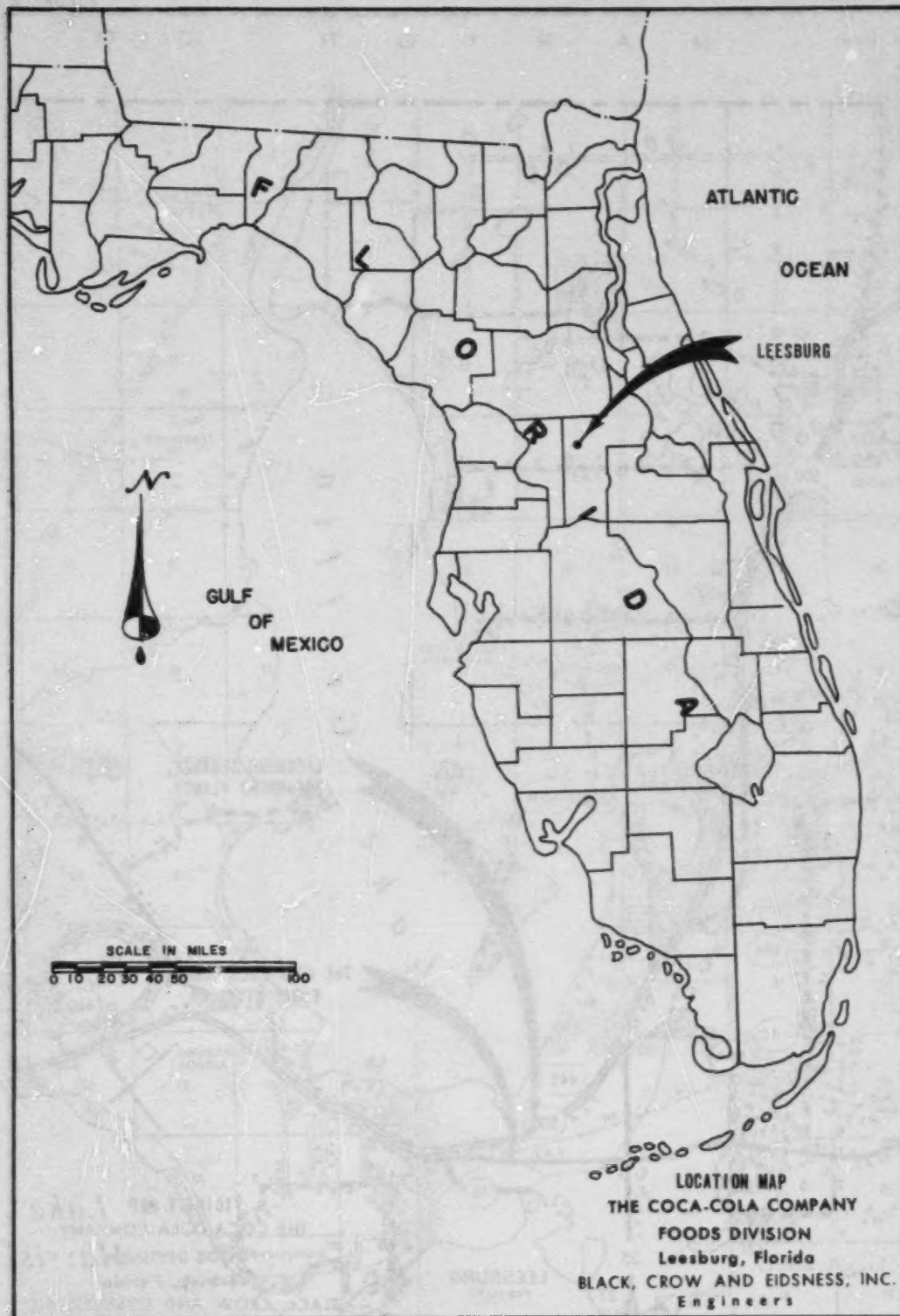
(1) Phosphorus, as PO₄

(2) Suspended solids

TABLE 6
LEESBURG BIOTA - EXTENDED AERATION
THE COCA-COLA COMPANY
FOODS DIVISION

ORGANISMS	AERATION CHAMBER	CLARIFIER	POLISHING POND AND SLUDGE FLOCS	FINAL EFFLUENT
SULFUR BACTERIA				
BEGGIATOXA ALBA		•		
BACTERIA, OTHER				
BACILLI, FILAMENTOUS	•	•	•	
SPHAEROTILUS NATANS	•	•	•	
ZOOGLA RAMIGERA	•	•	•	
FUNGI				
BLUE GREEN ALGAE				
LANGBYA SP.		•		
GLEOTRICHIA SP.		•		
SCHIZOTHRIX CALCICOLA		•		
GREEN ALGAE				
ANKISTRODESMUS CONVOLUTUS				•
ANKISTRODESMUS FALCATUS				•
CHLORELLA SP.				•
SCENEDESMUS SP.				•
UNID.			•	•
VOLVOCALES				
CHLAMYDOMONAS SP.			•	•
CHLOROGONIUM SP.			•	•
EUGLENOPHYCEAE				
EUGLENA AGILIS			•	•
EUGLENA GRACILIS		•		
DINOFAGELLATA				
MASSARTIA SP.				•
DIATOMS				
CYCIOTELLA SP.				•

FIGURE 1



[illegible]

FIGURE 3

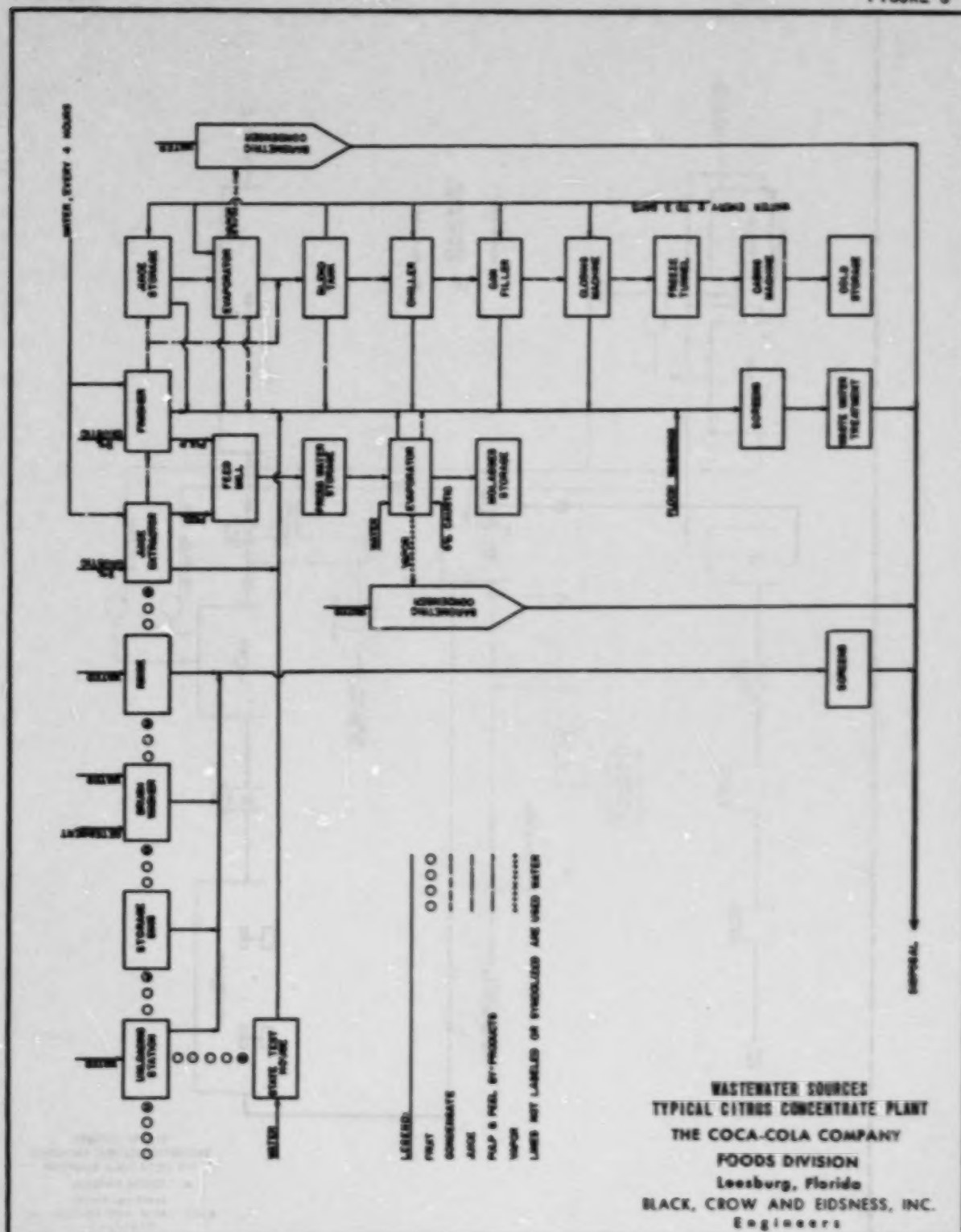


FIGURE 4

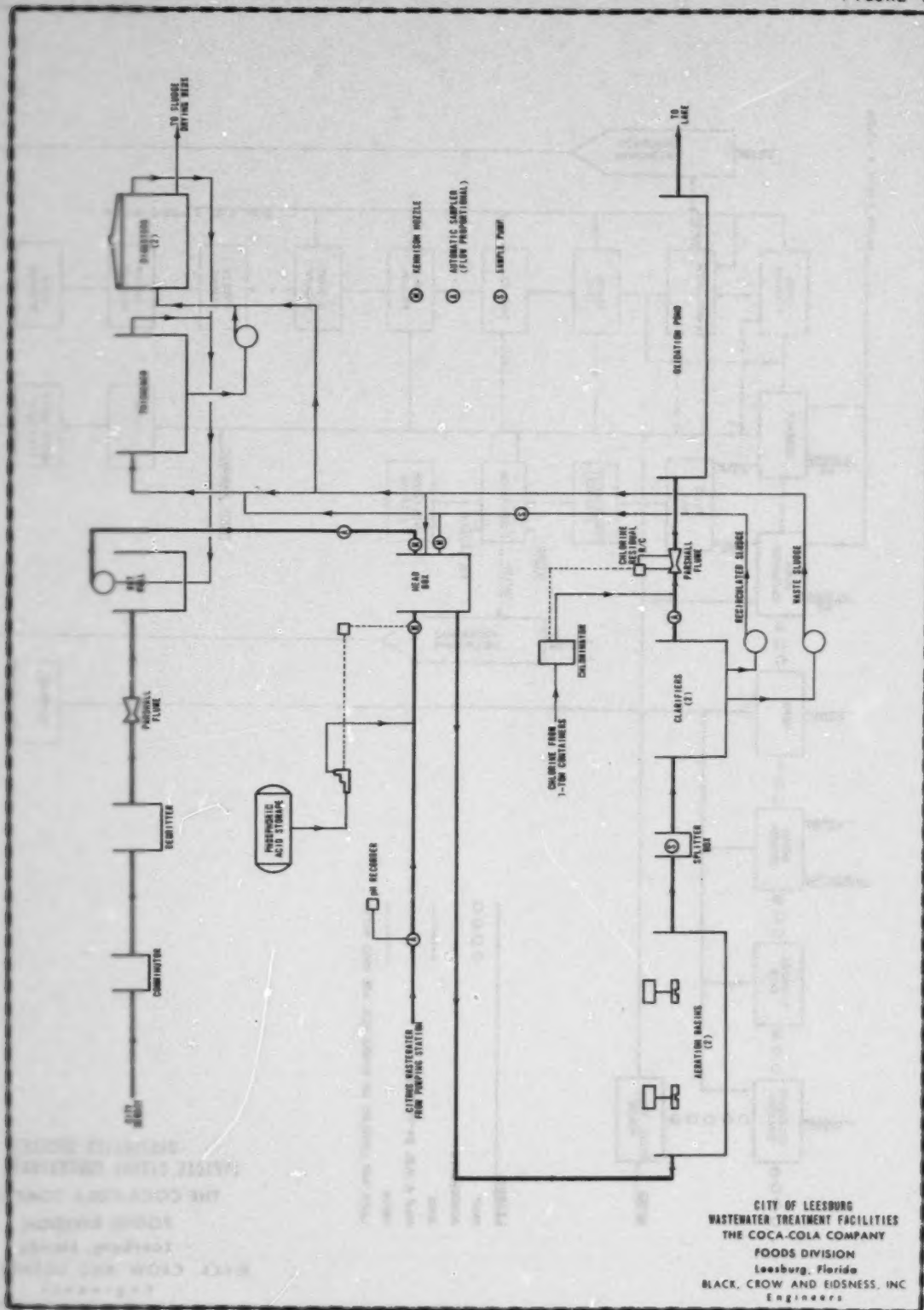


FIGURE 5

DAILY OPERATION RECORD																																																																																																															
City of Leesburg Sewage Treatment Plant				24-hr. period ending on: Weekday Month Day 19 Year																																																																																																											
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FIGURE 6

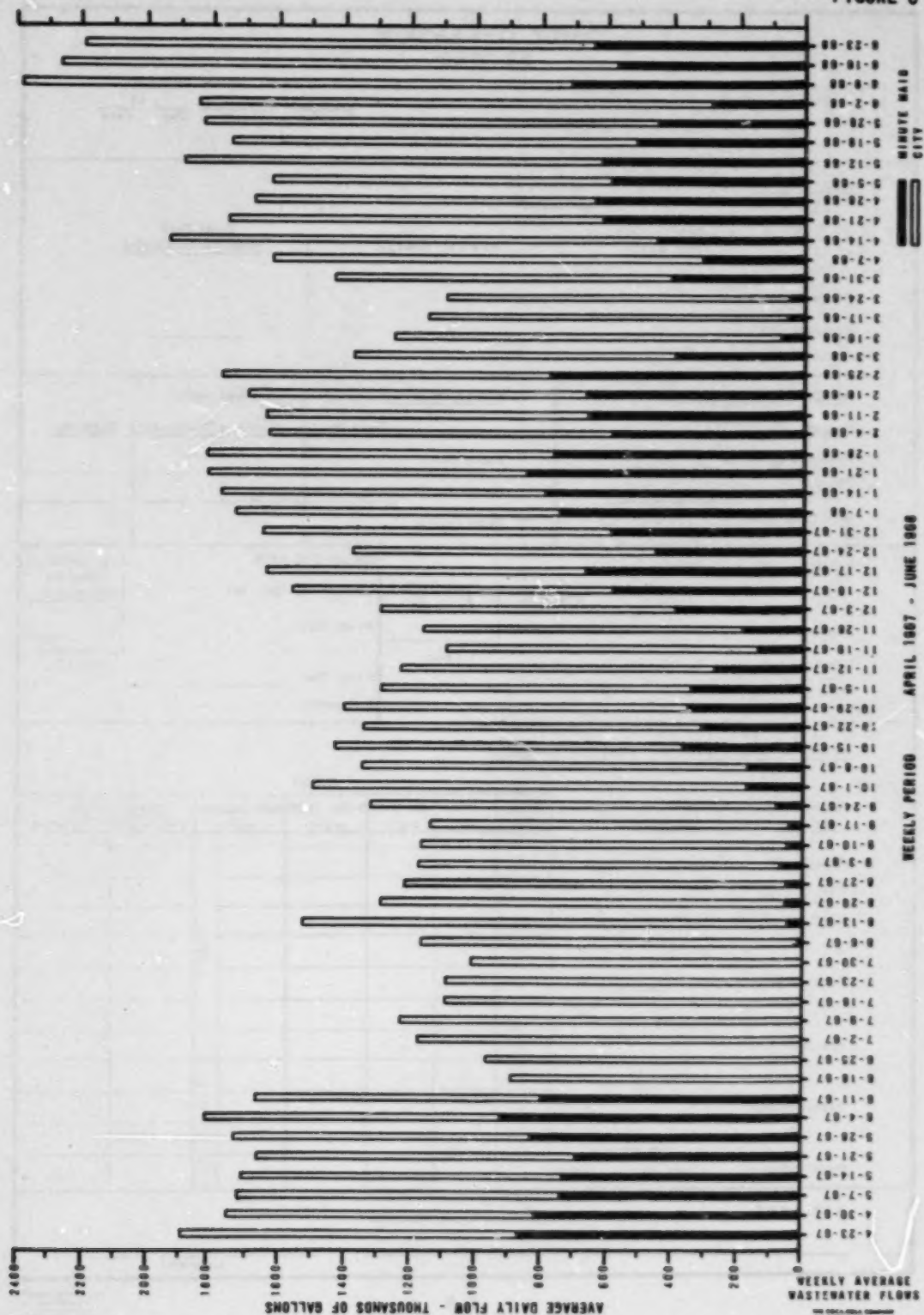


FIGURE 7

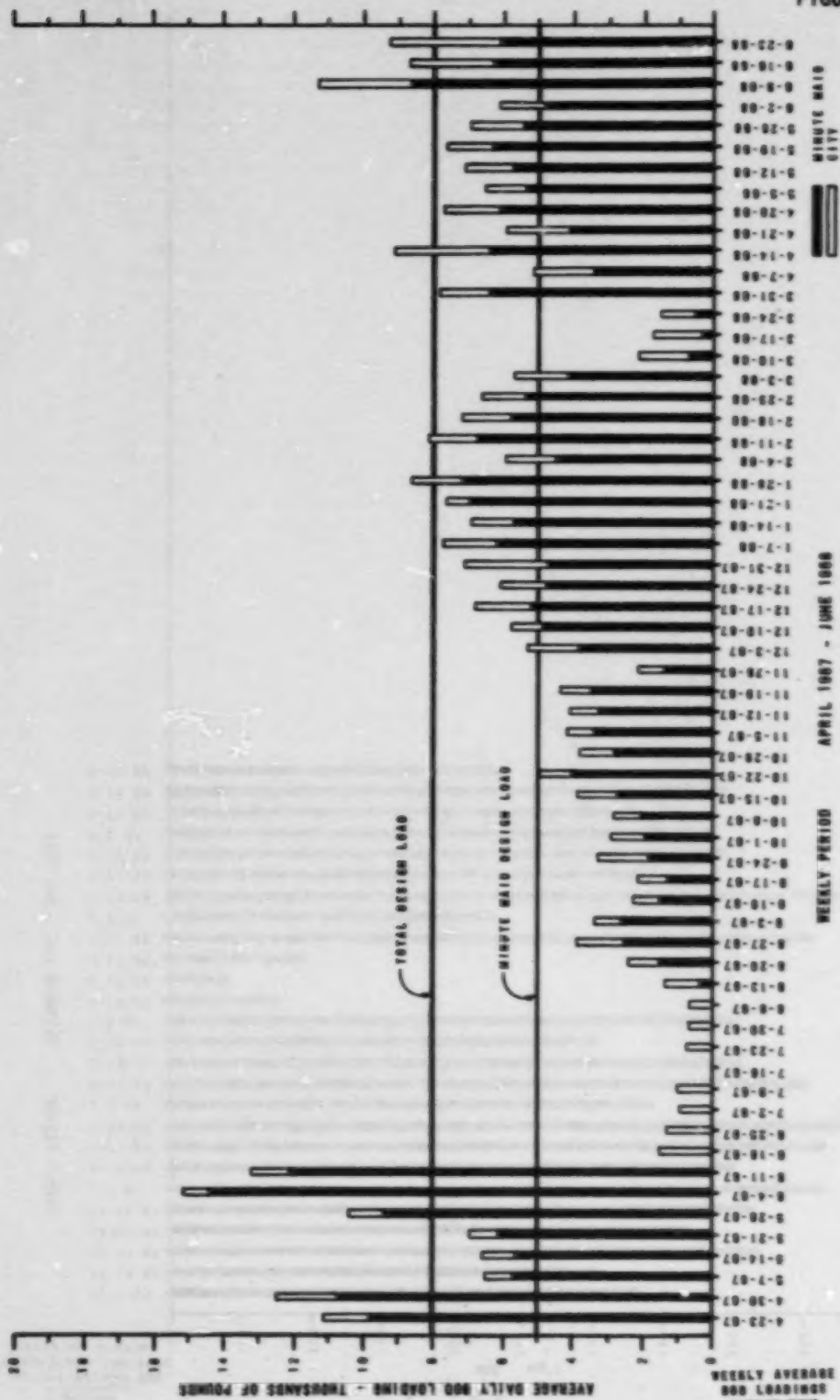
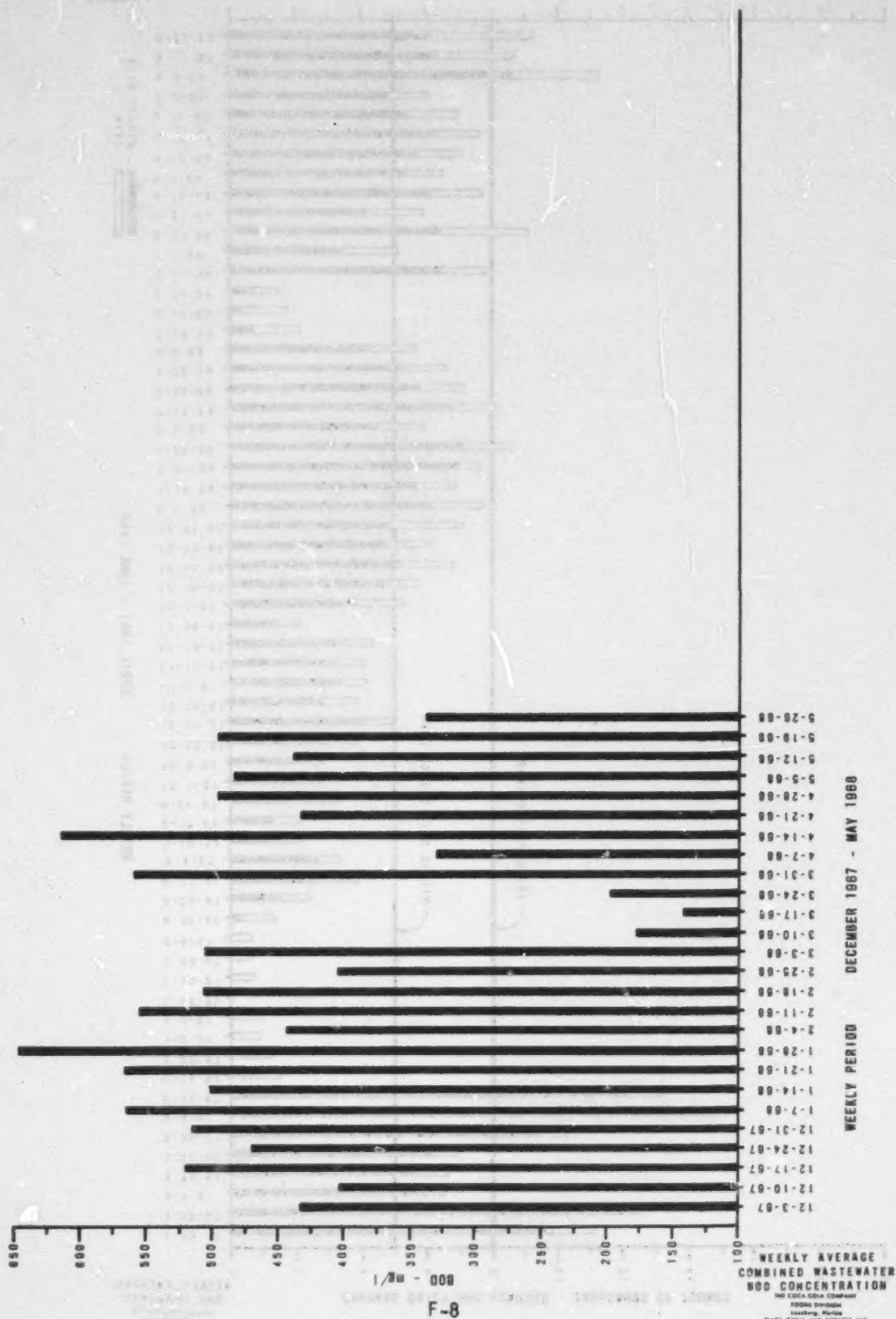


FIGURE 8



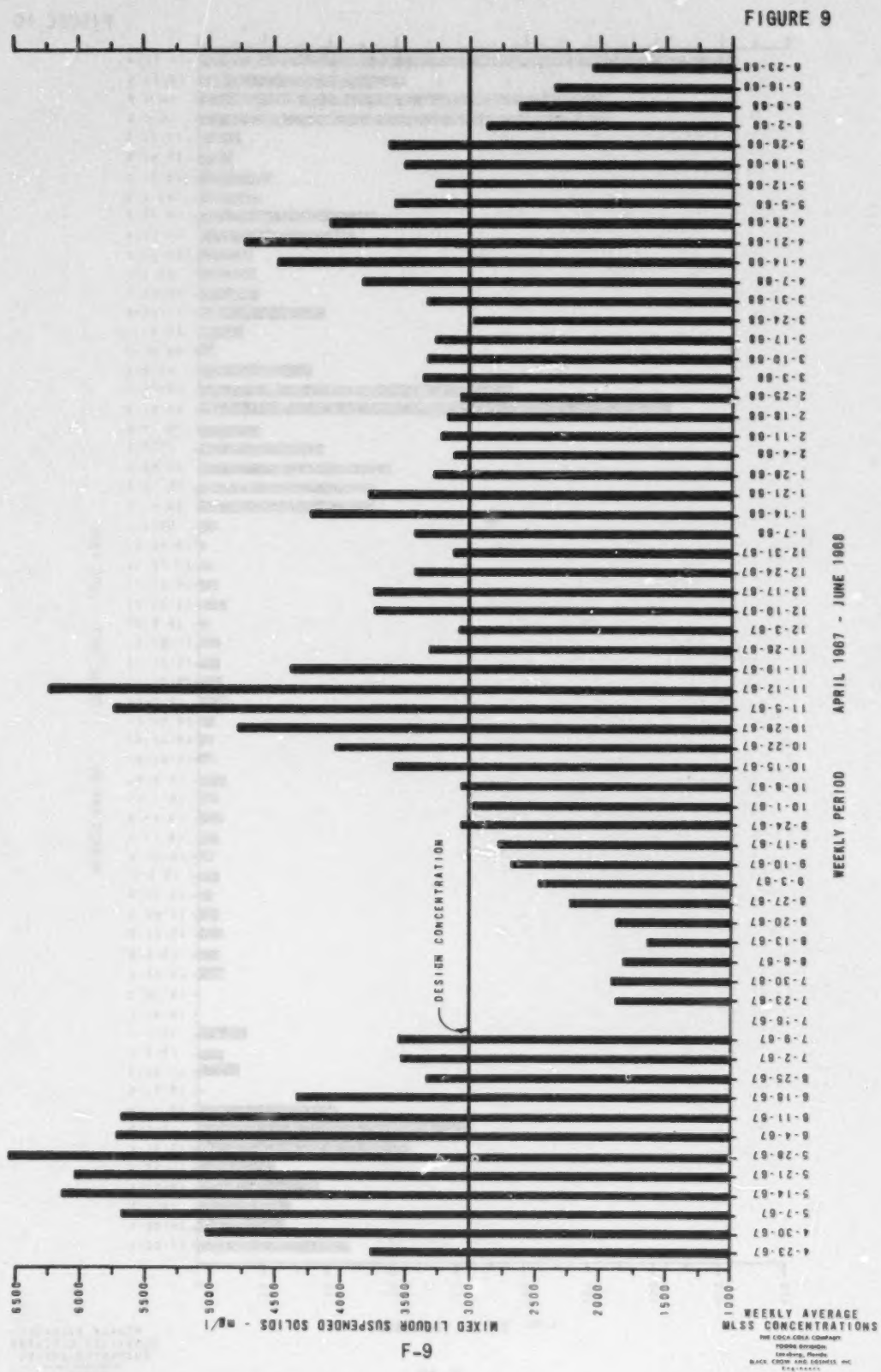
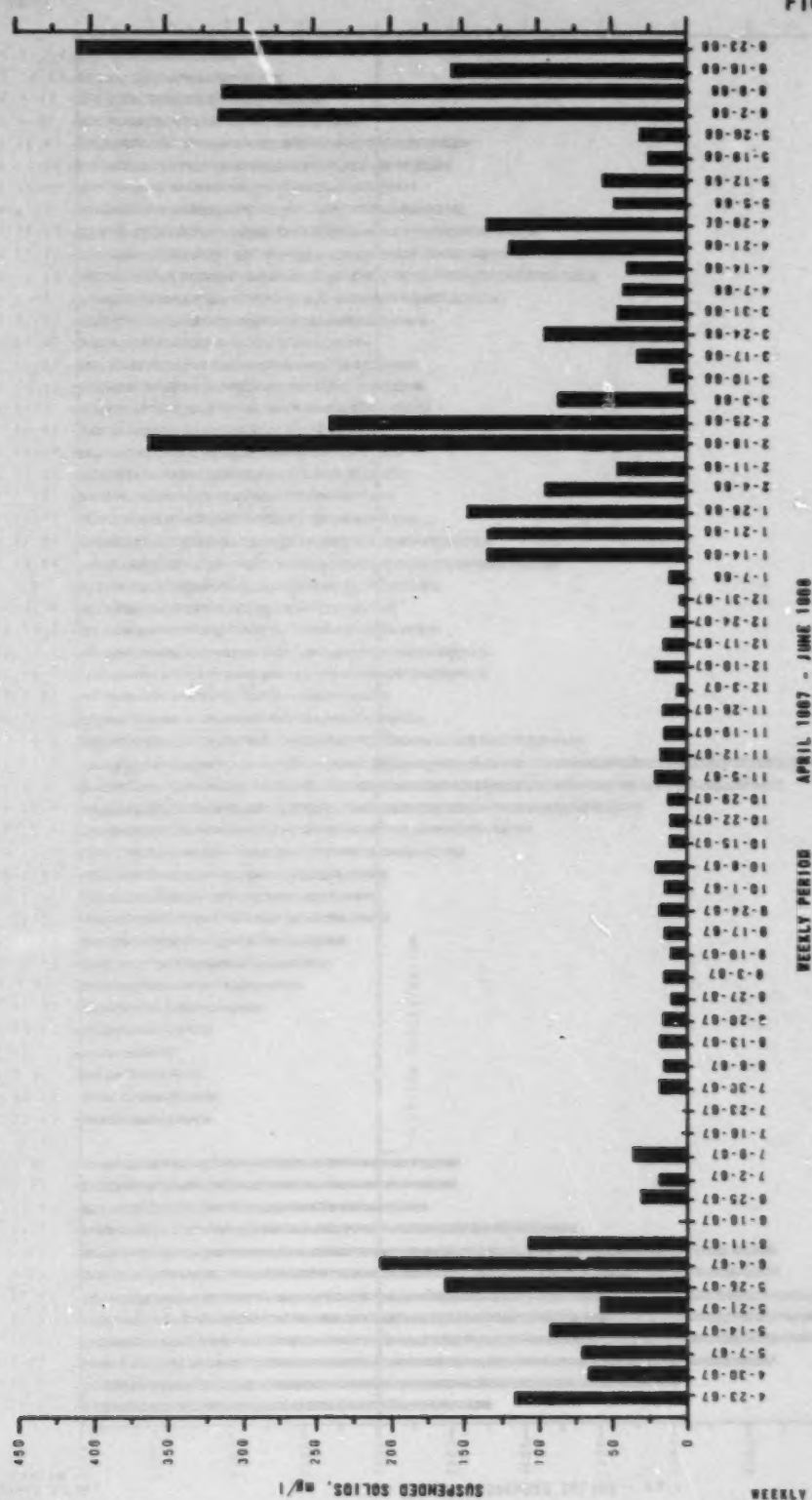


FIGURE 10



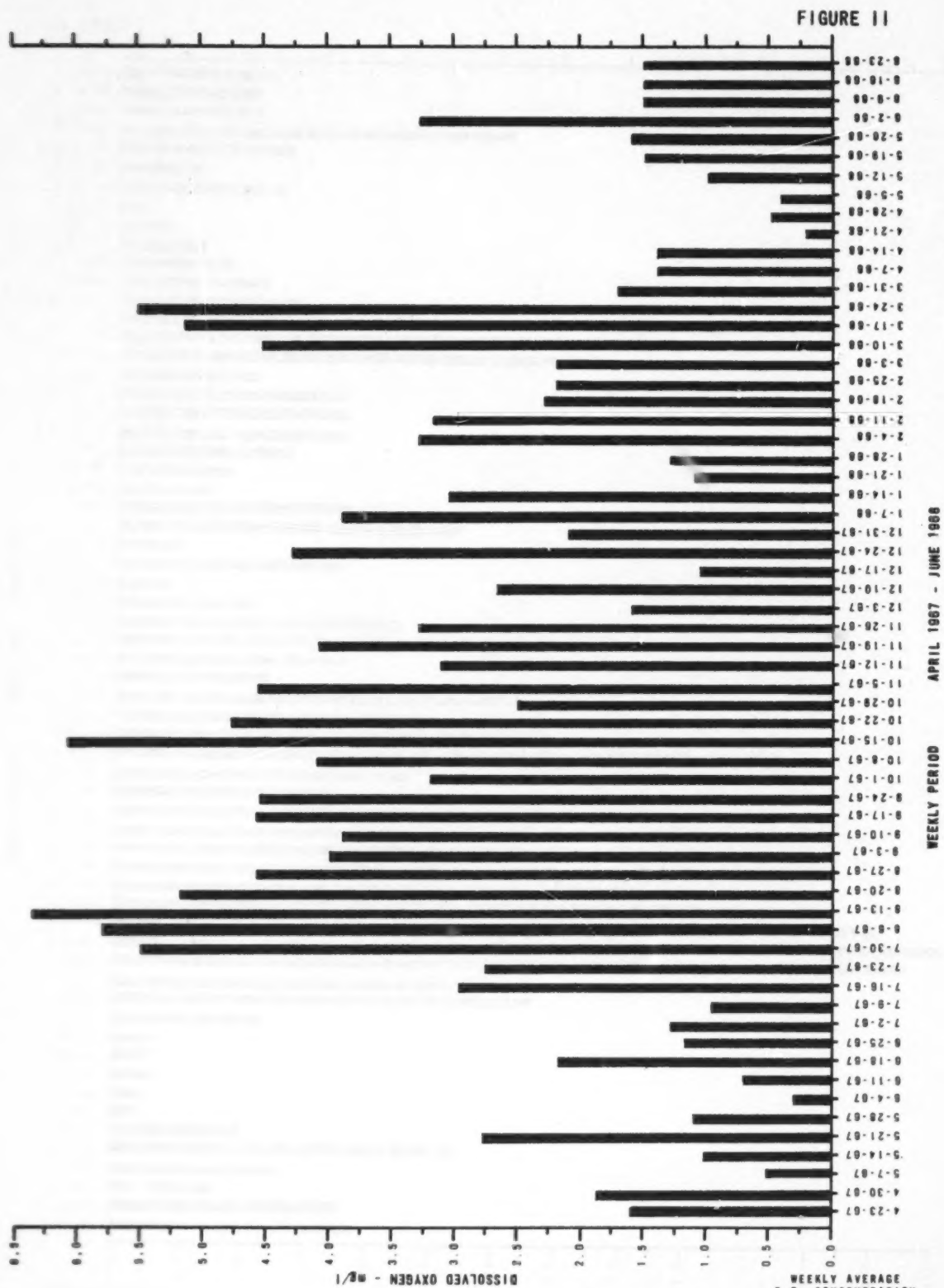


FIGURE 12

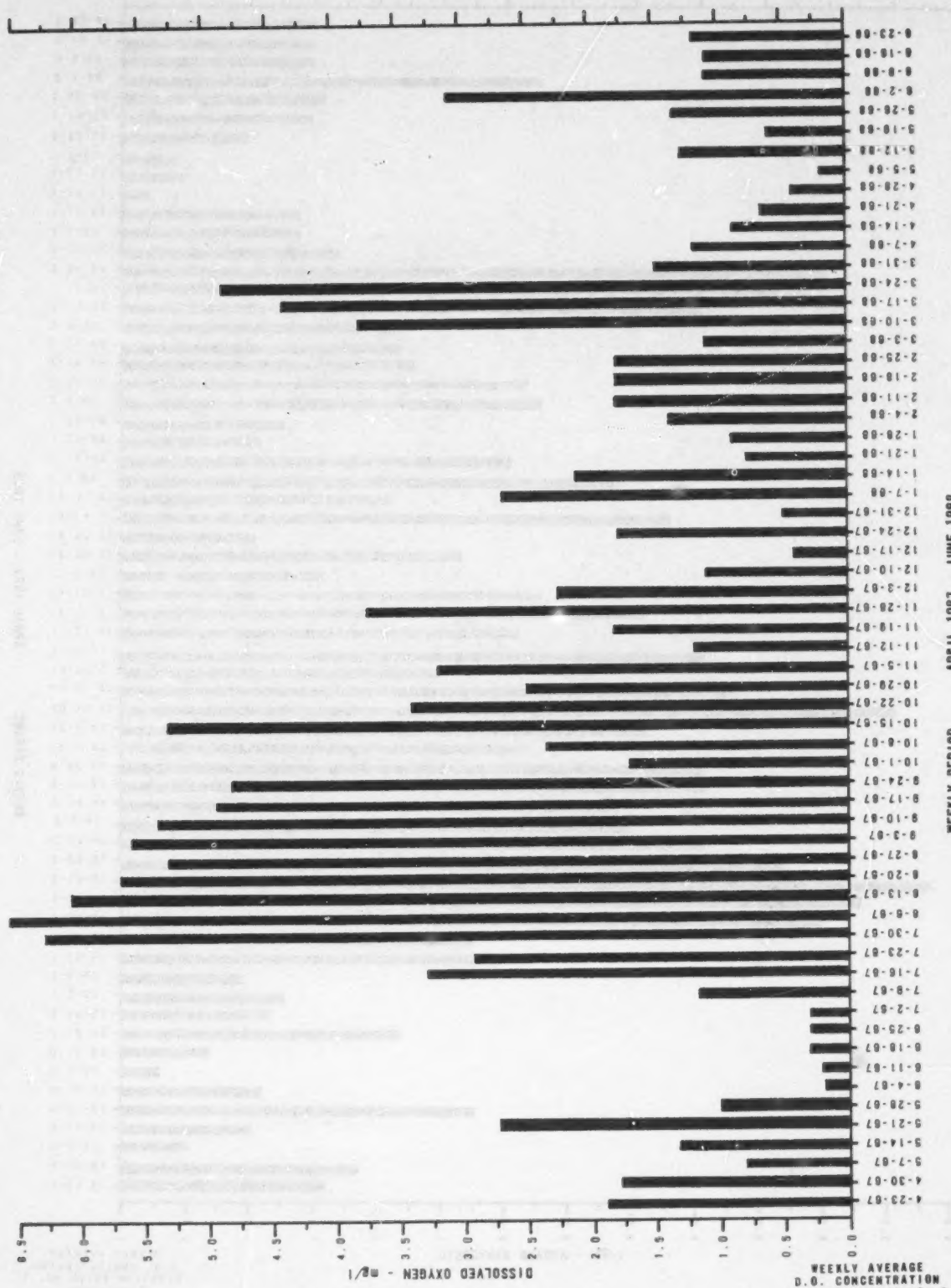


FIGURE 13

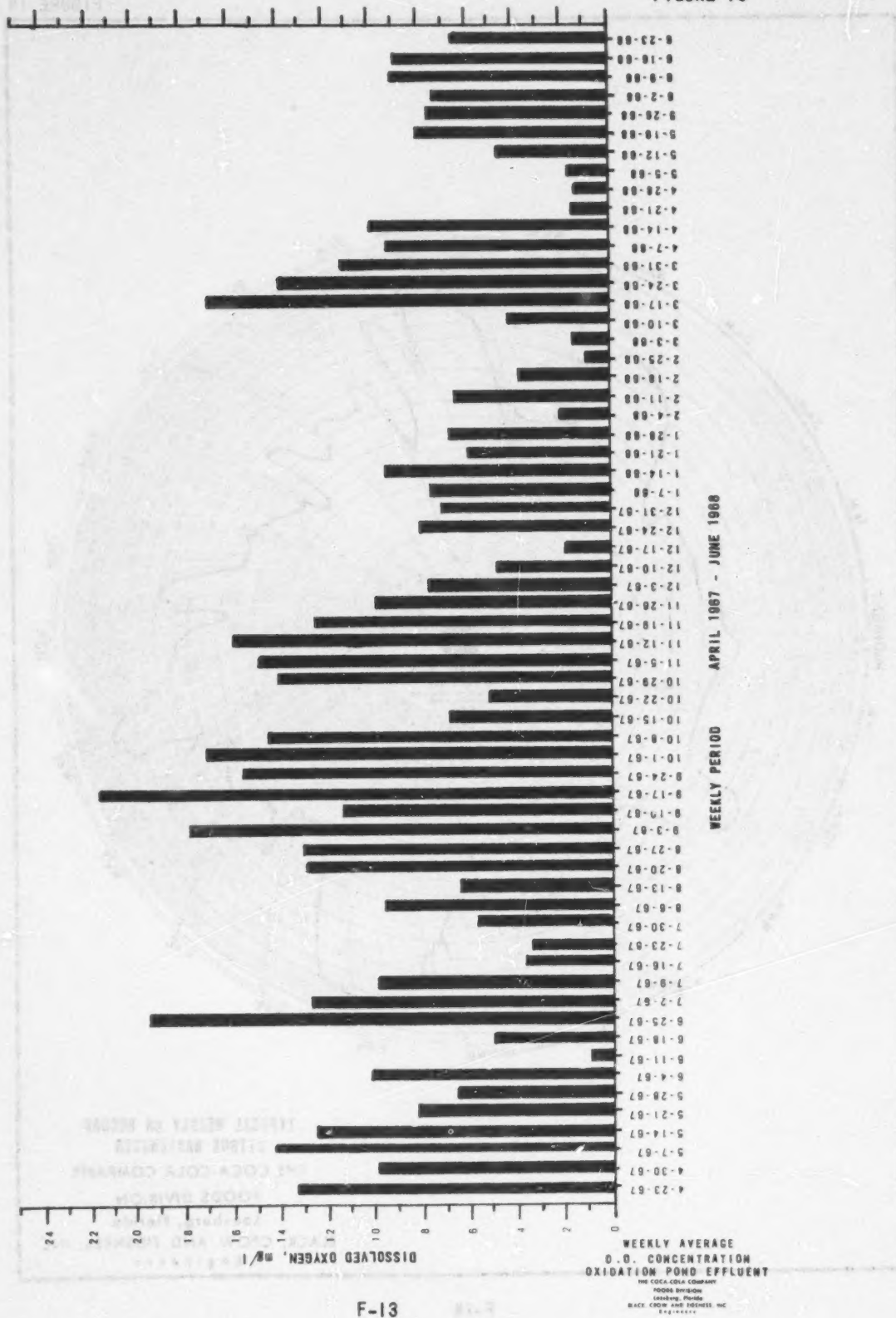


FIGURE 14

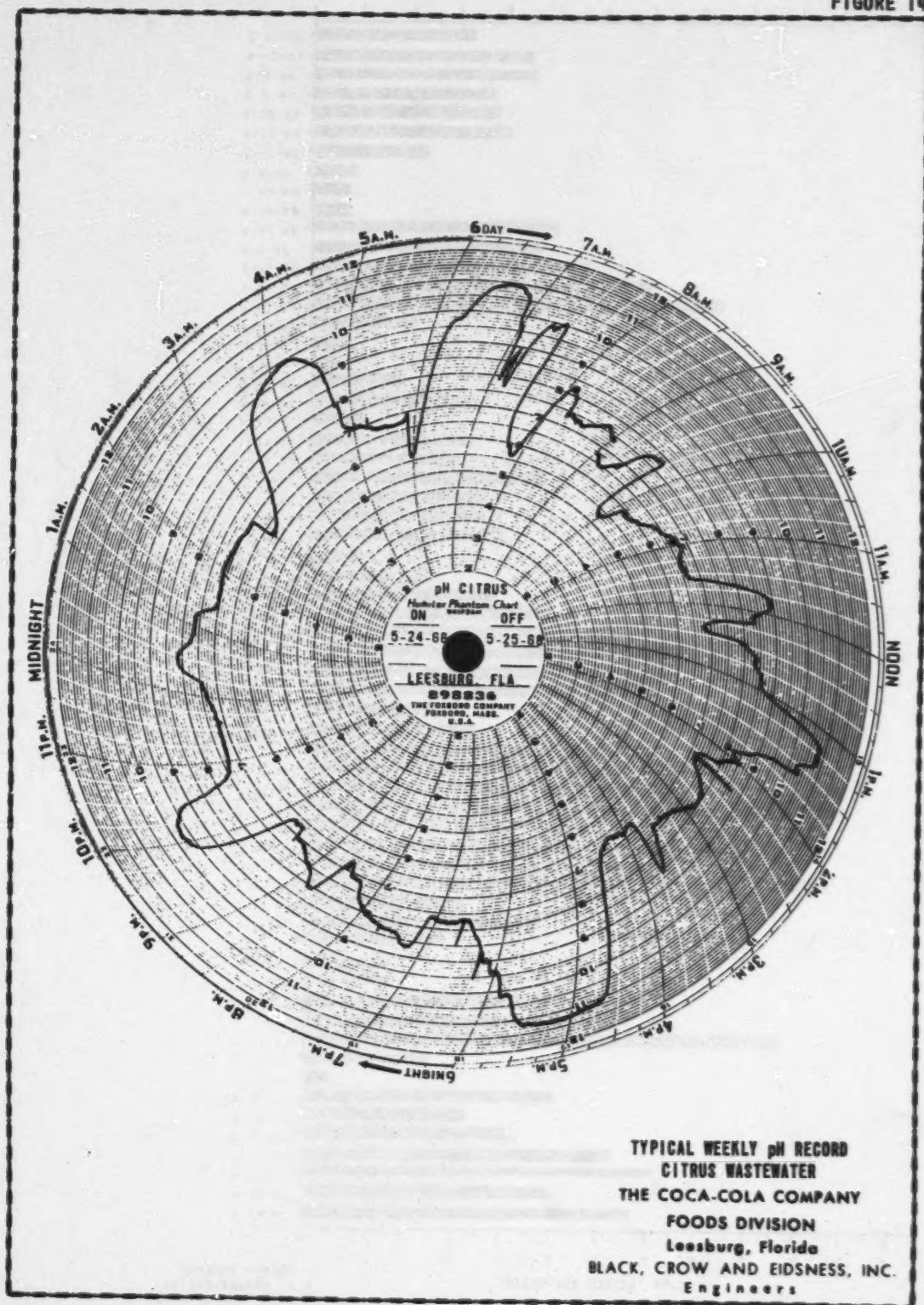


FIGURE 15

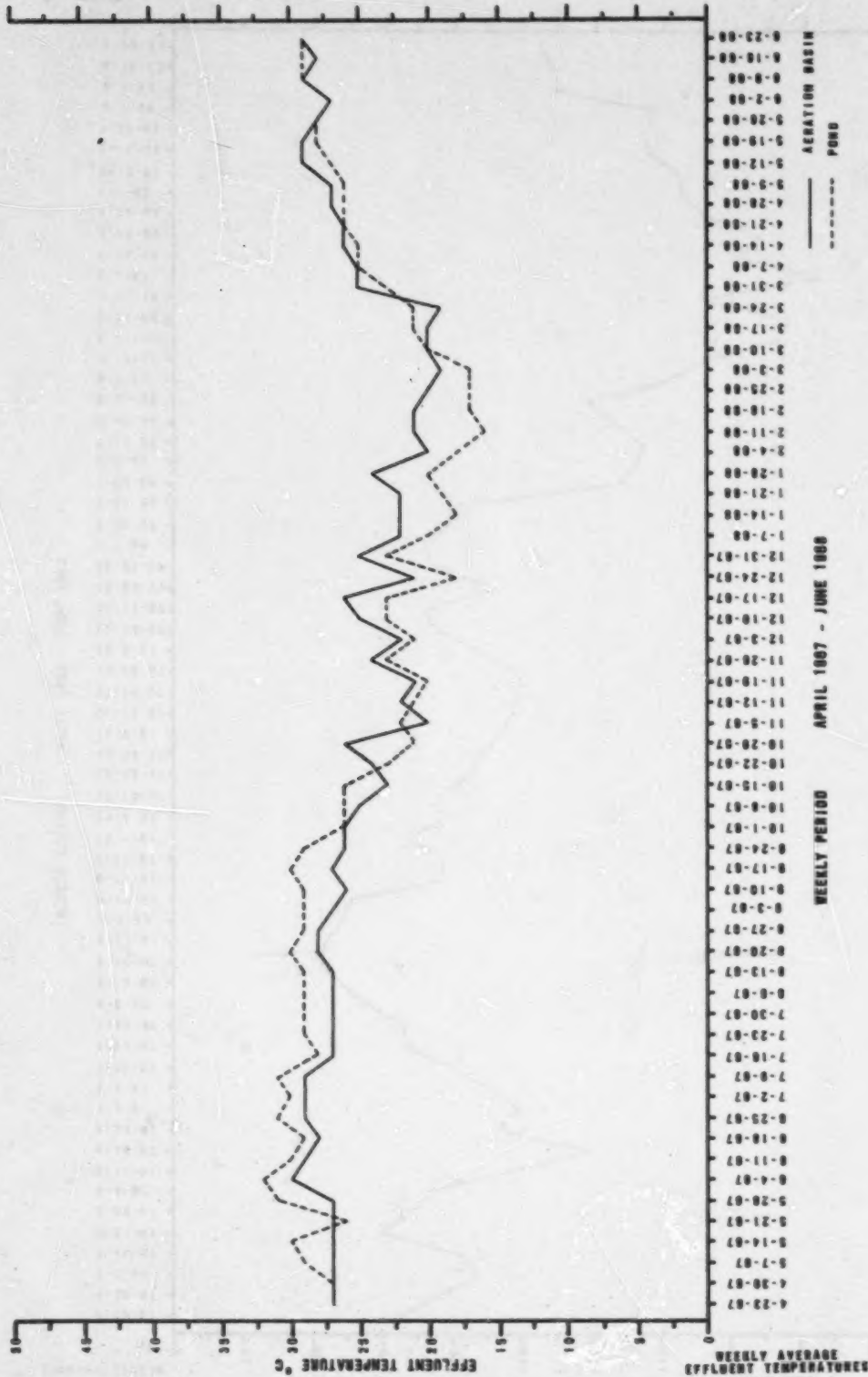
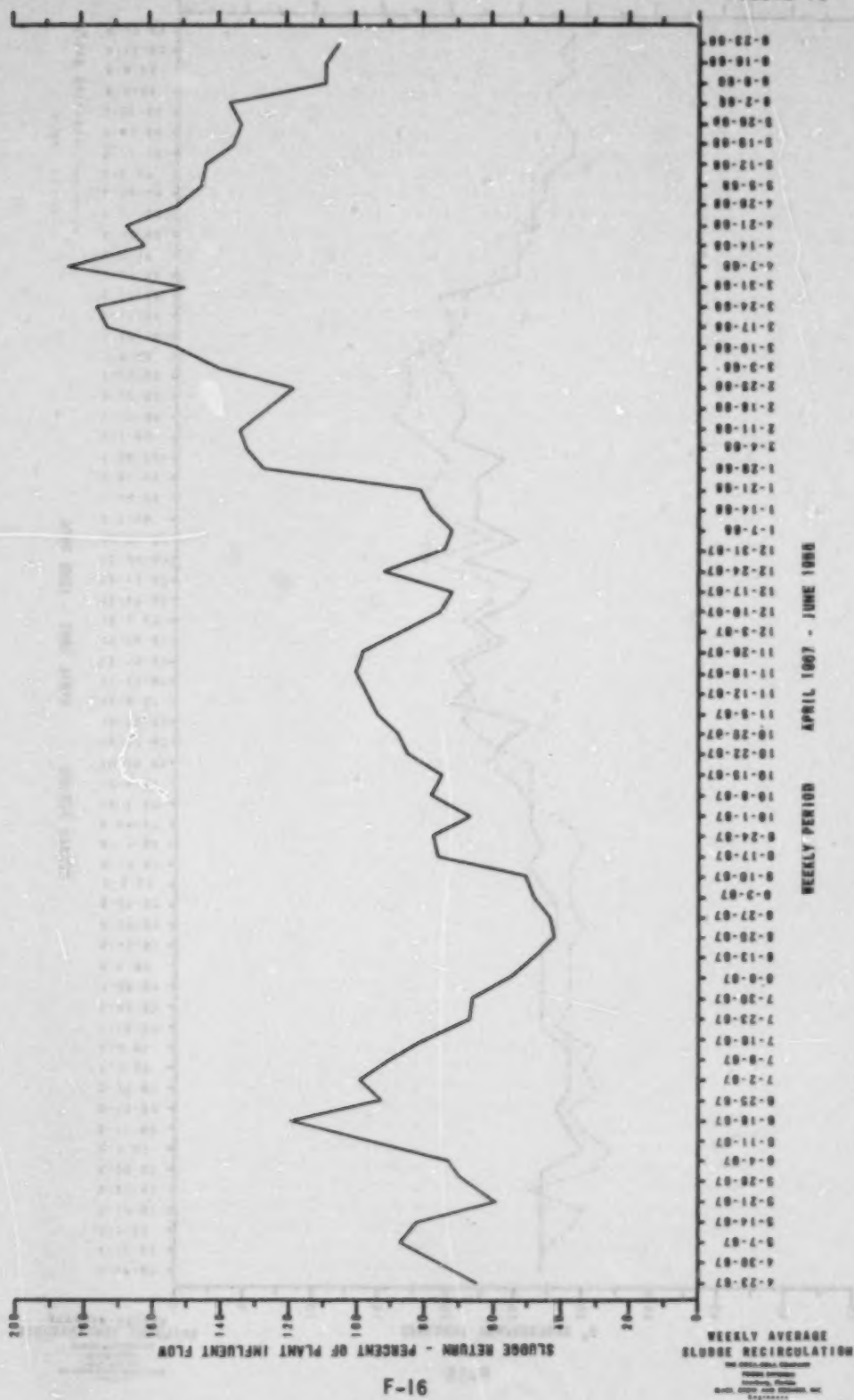


FIGURE 16





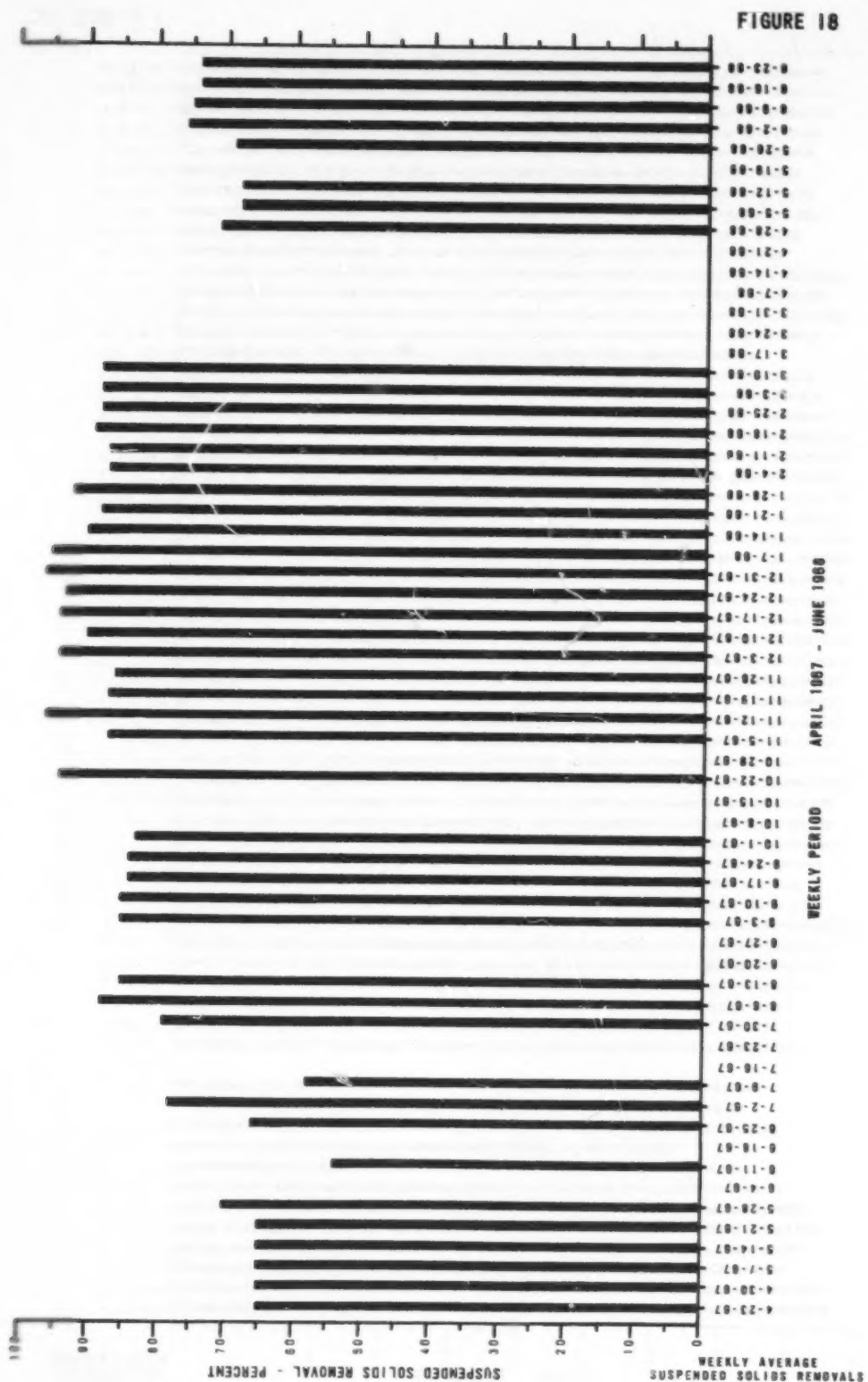


FIGURE 19

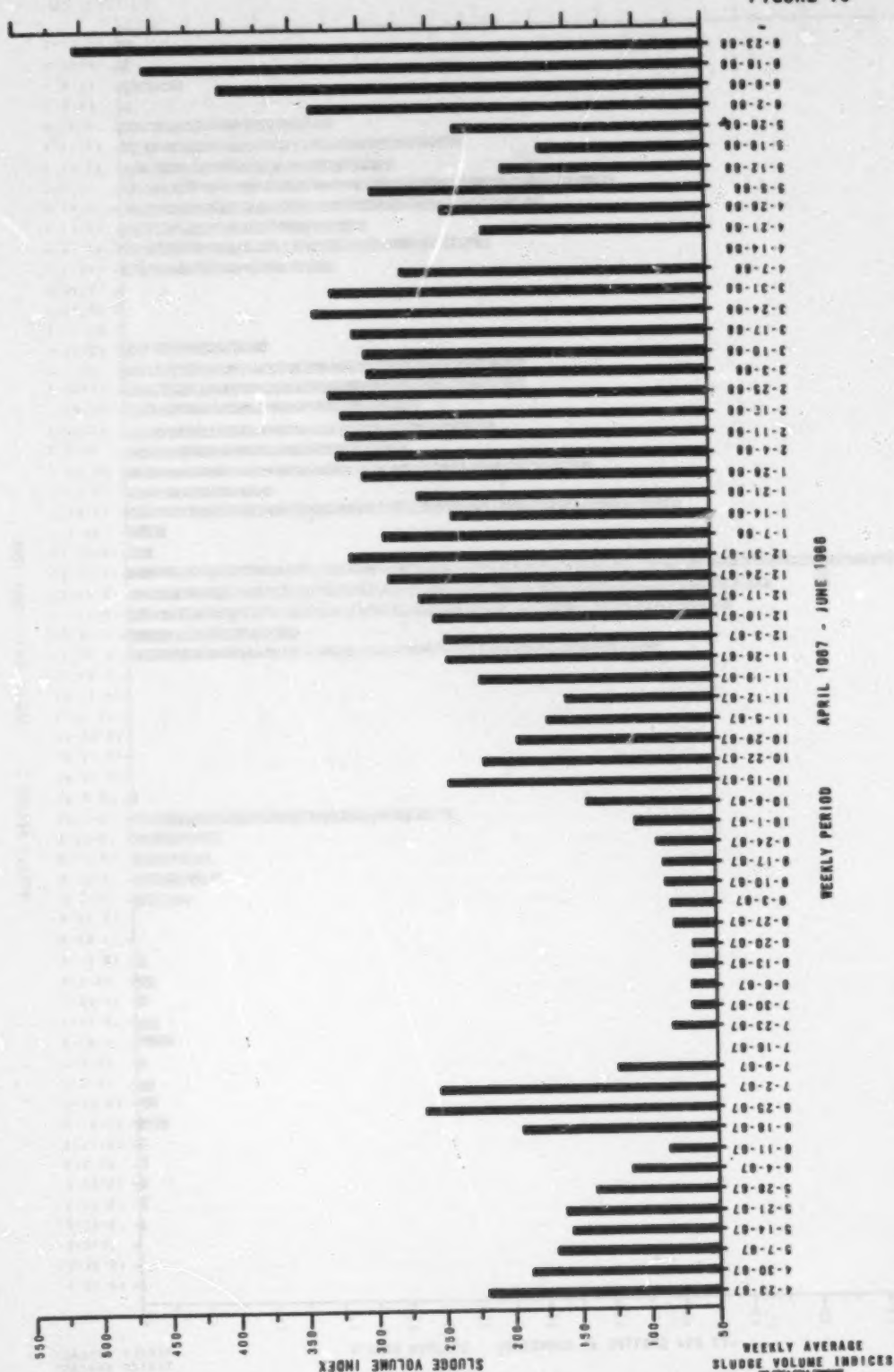
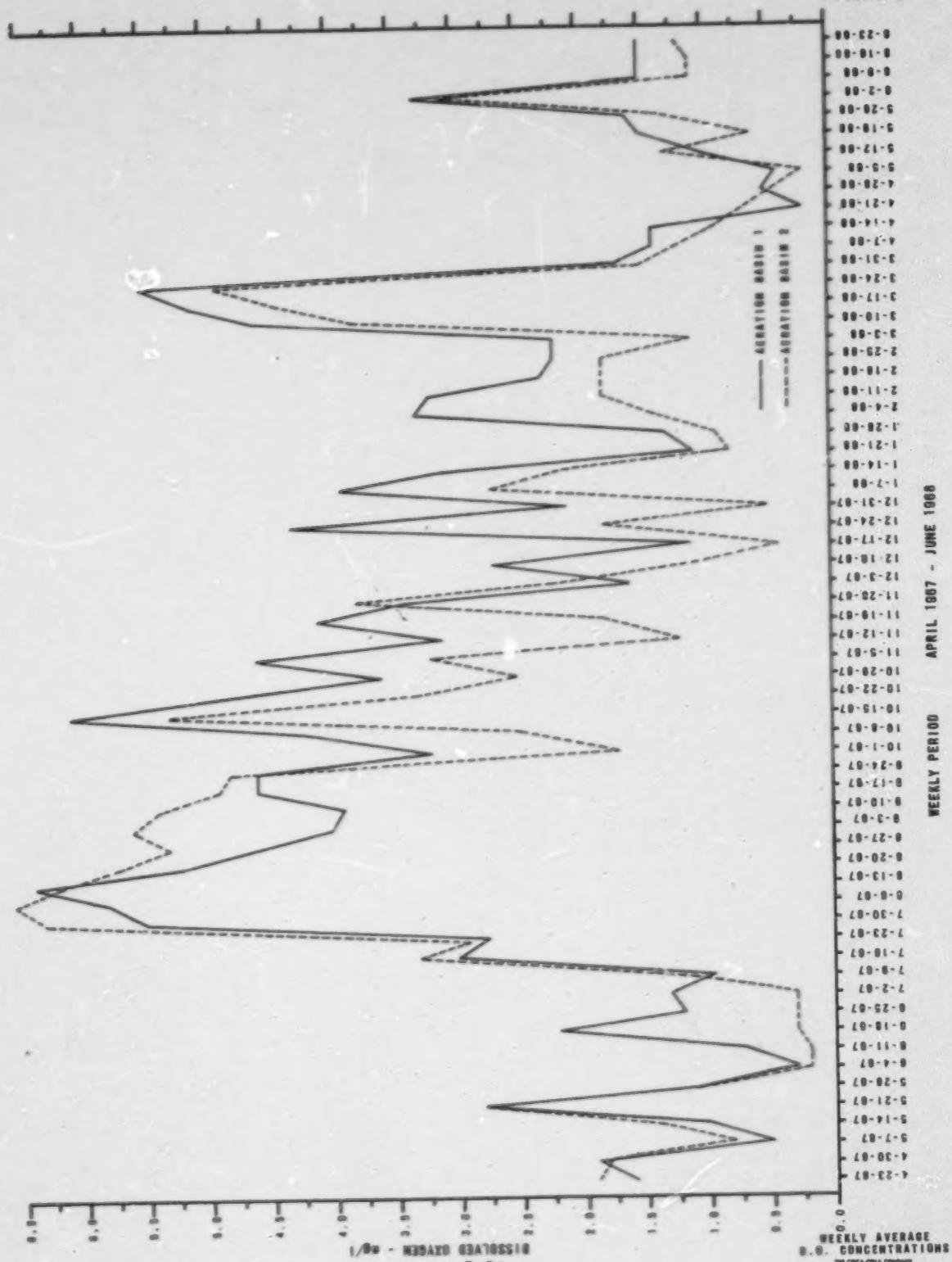




FIGURE 21



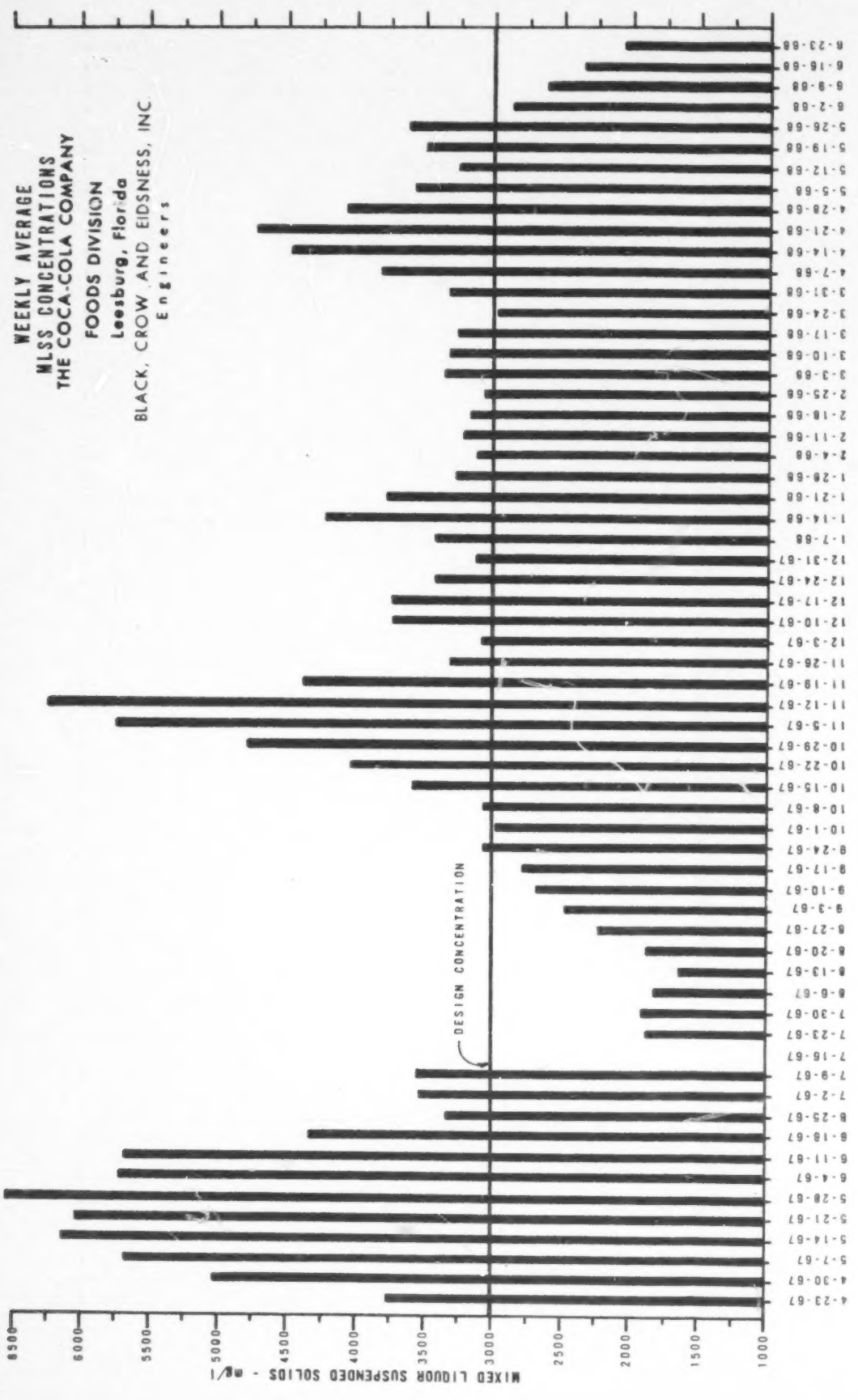
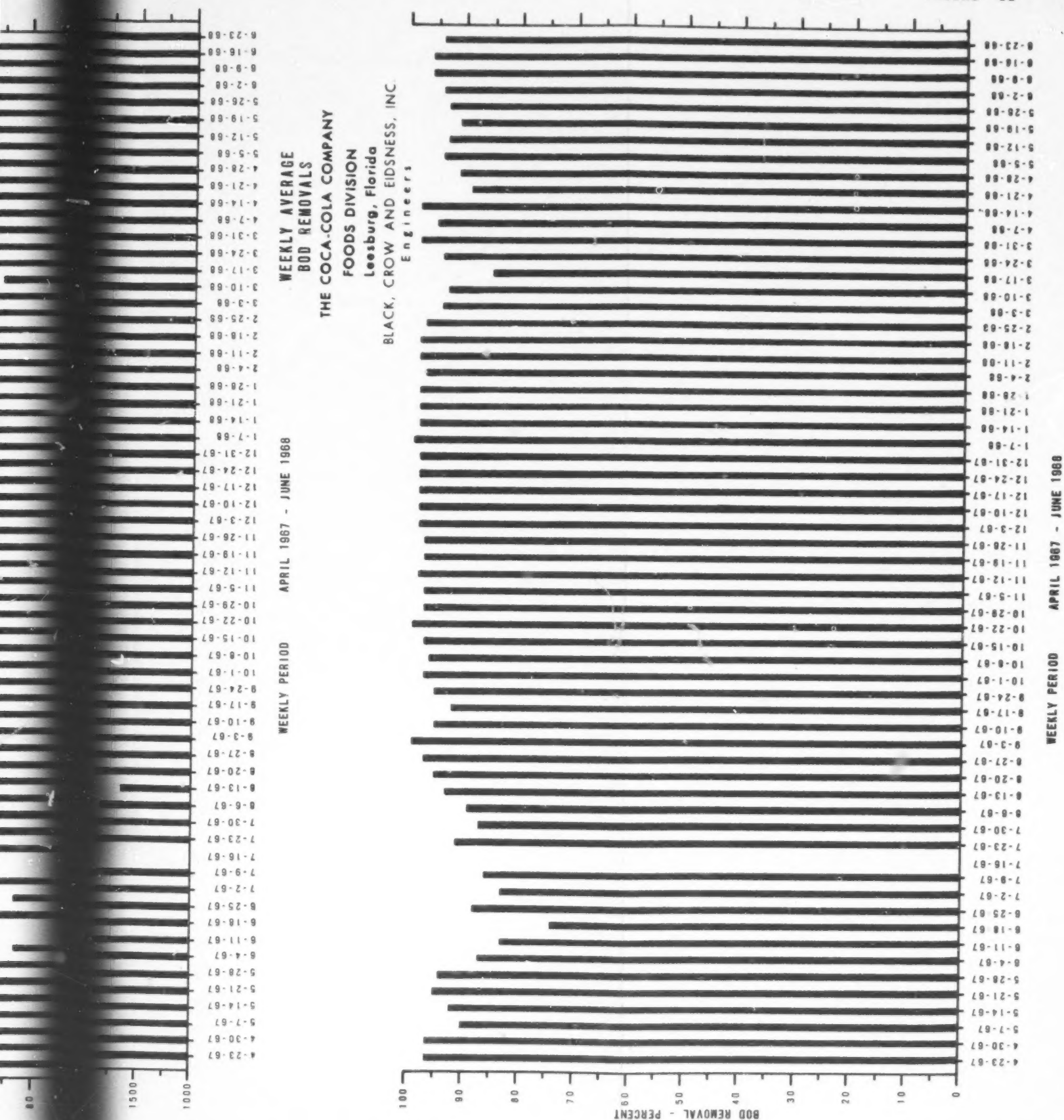


FIGURE 22



WEEKLY AVERAGE
MLSS CONCENTRATIONS
THE COCA-COLA COMPANY
FOODS DIVISION
Leesburg, Florida
BLACK, CROW AND EIDNESS, INC.
Engineers



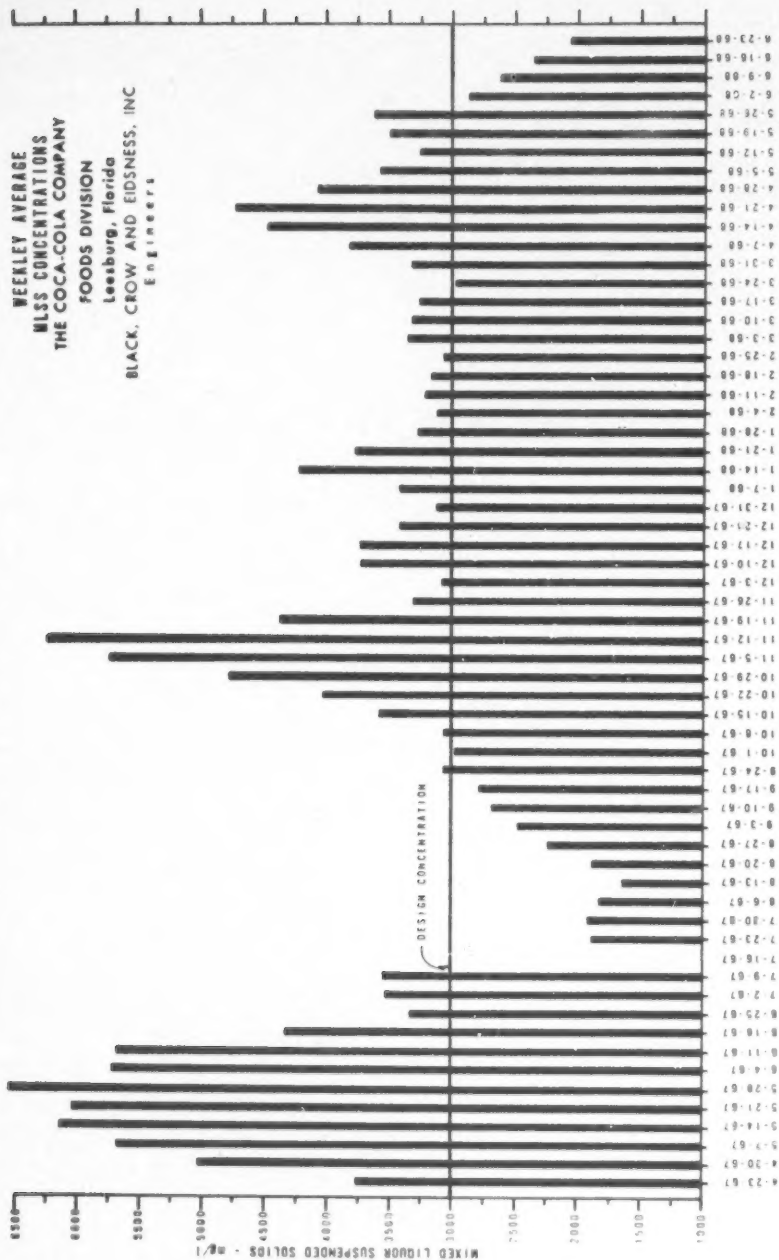
WEEKLY PERIOD APRIL 1967 - JUNE 1968

WEEKLY AVERAGE
SLUDGE WASTAGE
THE COCA-COLA COMPANY
FOODS DIVISION
Leesburg, Florida
BLACK, CROW AND EIDNESS, INC.
Engineers

80
55
50



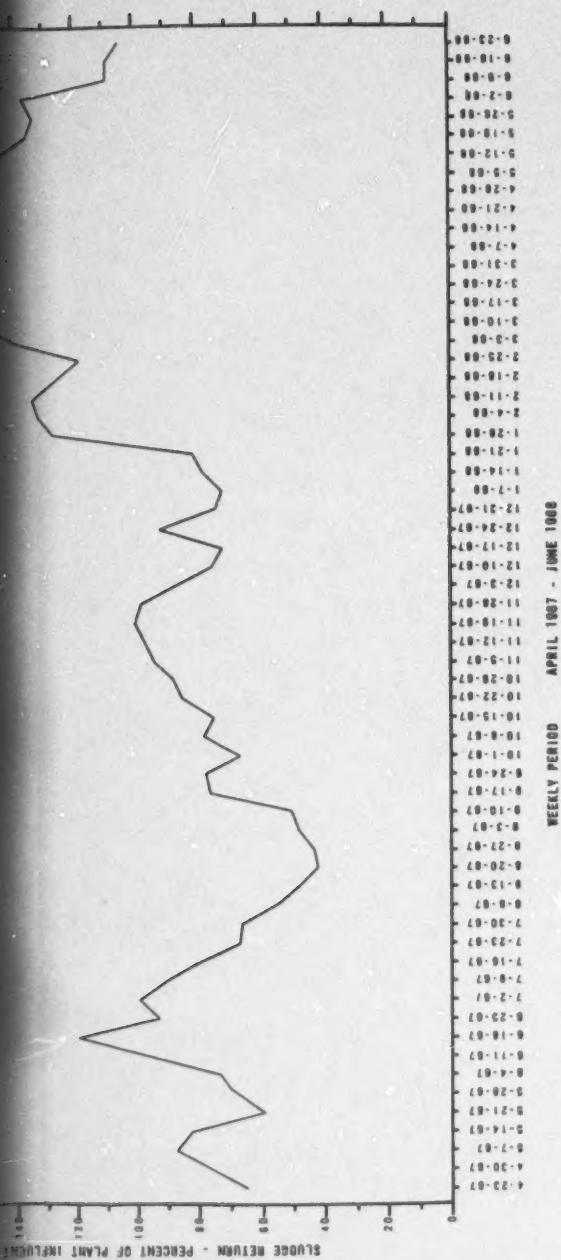
WEEKLY AVERAGE
MLSS CONCENTRATIONS
THE COCA-COLA COMPANY
FOODS DIVISION
Leesburg, Florida
BLACK, CROW AND EIDNESS, INC.
Engineers



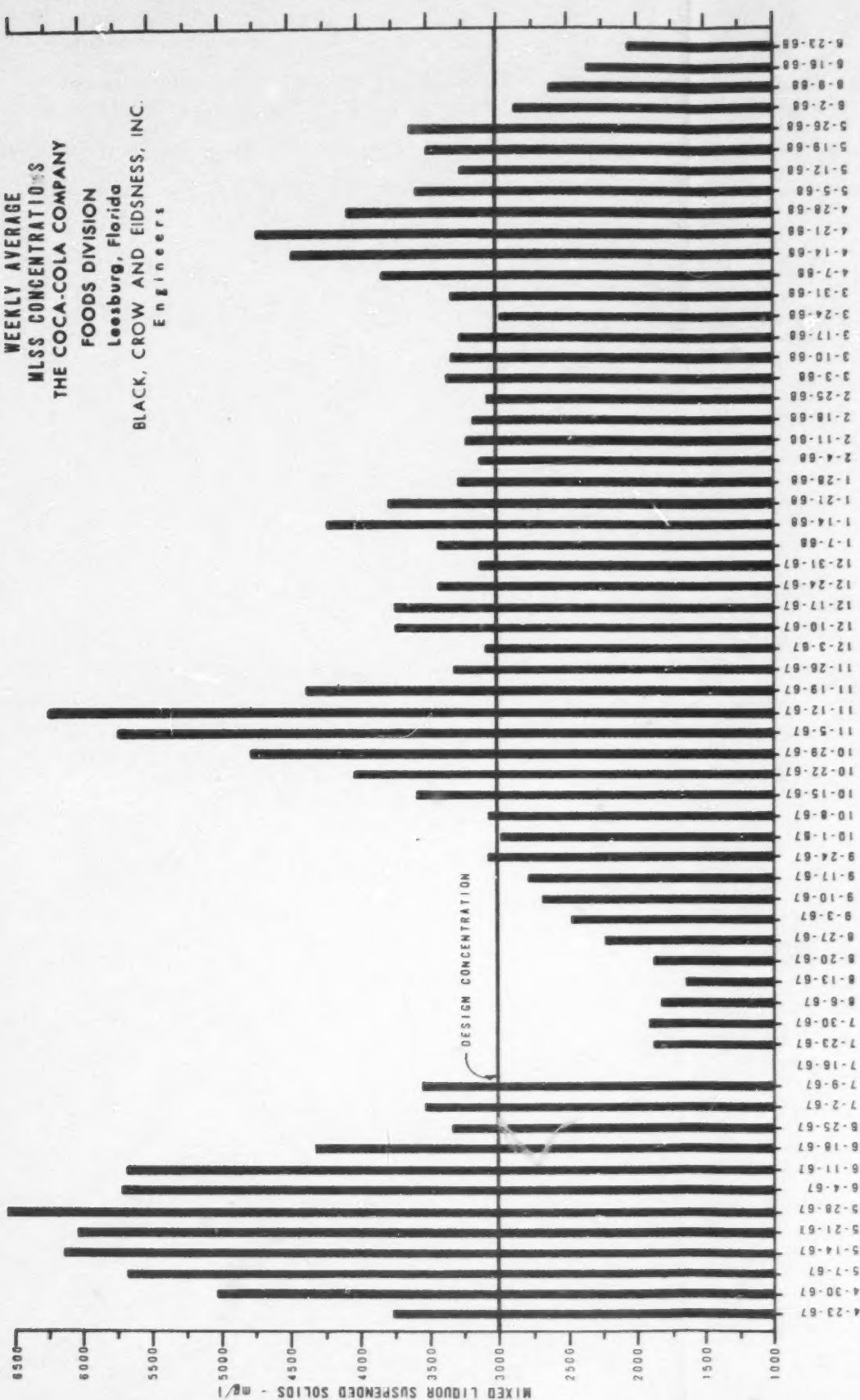
WEEKLY AVERAGE
SLUDGE RECIRCULATION
THE COCA-COLA COMPANY
FOODS DIVISION
Leesburg, Florida
BLACK, CROW AND EIDNESS, INC.
Engineers



FIGURE 24



WEEKLY AVERAGE
MLSS CONCENTRATIONS
THE COCA-COLA COMPANY
FOODS DIVISION
Leesburg, Florida
BLACK, CROW AND EIDNESS, INC.
Engineers

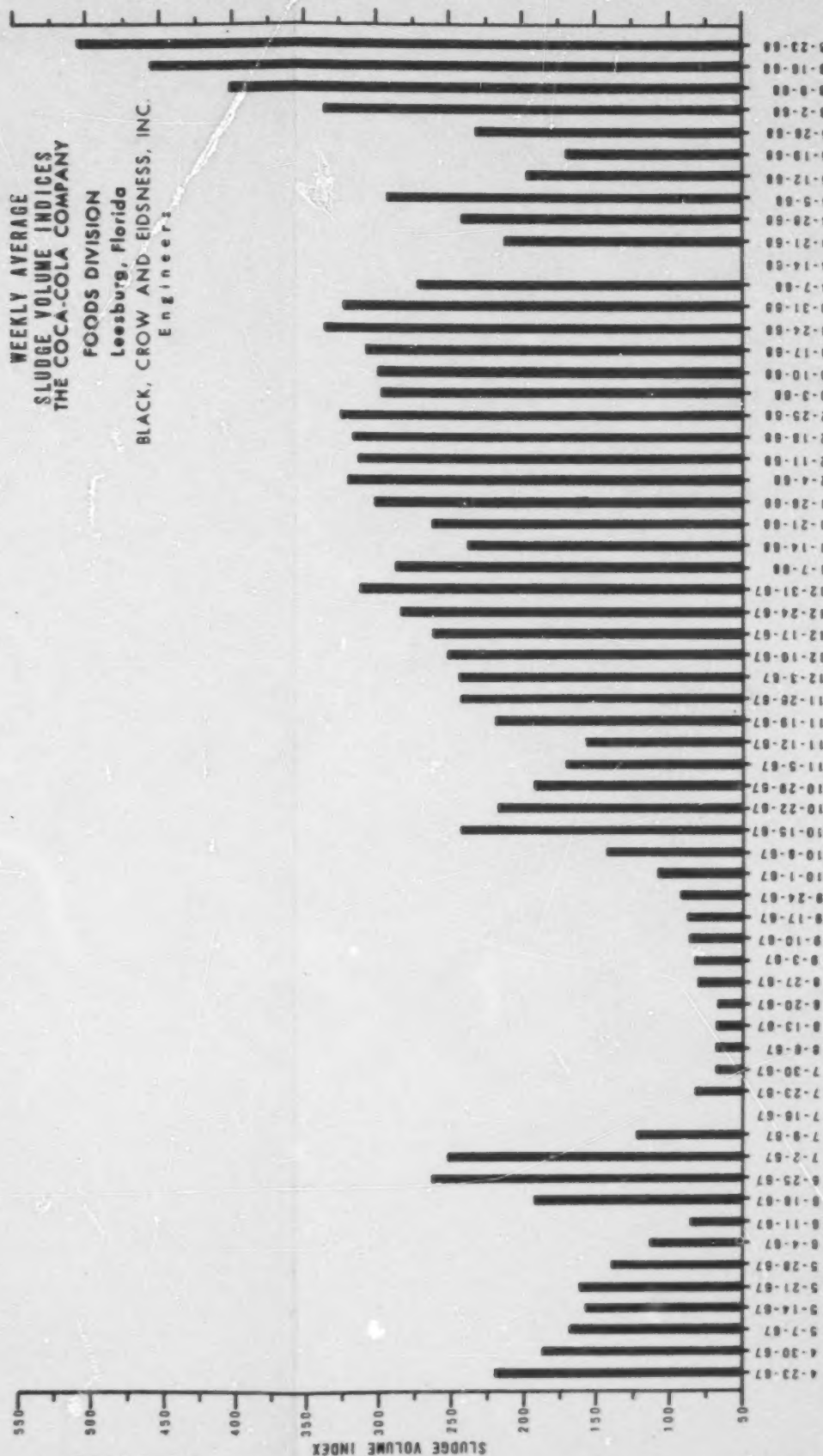


WEEKLY AVERAGE
SLUDGE VOLUME INDICES
THE COCA-COLA COMPANY
FOODS DIVISION
Leesburg, Florida
BLACK, CROW AND EIDNESS, INC.
Engineers



WEEKLY AVERAGE
SLUDGE VOLUME INDICES
THE COCA-COLA COMPANY
FOODS DIVISION
Leesburg, Florida
BLACK, CROW AND EIDNESS, INC.
Engineers

FIGURE 25

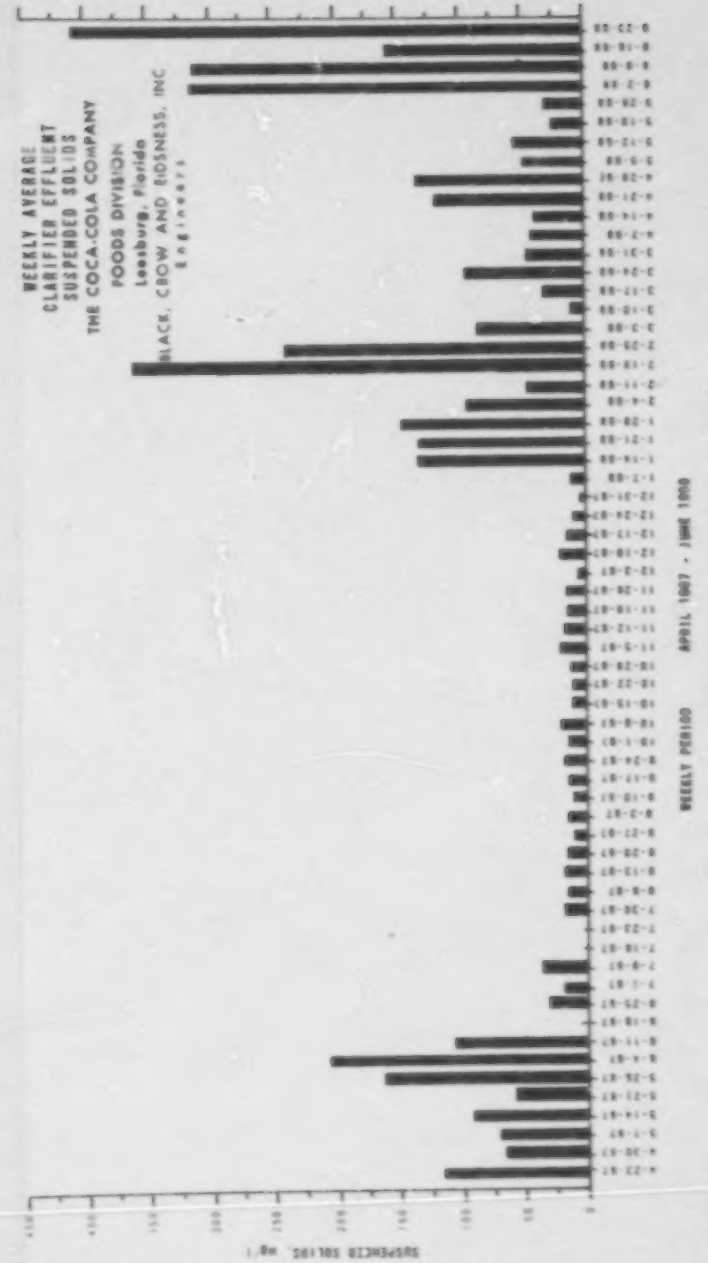


WEEKLY AVERAGE
 SLUDGE REGULATION
 THE COCA-COLA COMPANY
 FOODS DIVISION
 Leesburg, Florida
 BLACK, CROW AND EIDNESS, INC.
 Engineers



WEEKLY AVERAGE
 SLUDGE VOLUME INDICES
 THE COCA-COLA COMPANY
 FOODS DIVISION
 Leesburg, Florida
 BLACK, CROW AND EIDNESS, INC.
 Engineers





**LABORATORY STUDIES
1966-67 CITRUS PROCESSING SEASON**

**THE COCA-COLA COMPANY, FOODS DIVISION
LEESBURG, FLORIDA**

**Federal Water Quality Administration
Grant No. WPRD 38-01-67**

During December 1966, January, and February 1967, a series of laboratory tests were conducted at the Phelps Research Laboratory. The purposes of these tests were:

1. To develop a biological floc acclimated to a 50-50 mixture of sewage and citrus waste;
2. To establish the biological oxidation rate (K_1) for citrus waste and for a 50-50 mixture of citrus waste and domestic sewage from the Leesburg area;
3. To determine the effect of various mixed liquor suspended solids (MLSS) concentrations on the removal of BOD and the buildup of sludge mass.

Test No. 1

Purpose: Acclimation of a biological floc.

Procedure:

Twelve liters of a 50-50 mixture of degritted Leesburg sewage and citrus waste were placed in a 15-liter container. One liter of returned activated sludge from the University of Florida Campus Sewage Treatment Plant was added and the mixture aerated for 24 hours.

At the end of 24 hours the air supply was cut off and the mixture allowed to settle for 30 minutes. Eight liters of the supernatant were decanted from the top, leaving 5 liters of sludge mixture. Eight liters of a 50-50 sewage-citrus waste mixture were added and the air supply turned on.

This procedure was repeated daily for two and one-half months.

The mixed liquor suspended solids settled rapidly and no odor problems were experienced.

In an effort to reduce the amount of travel between Gainesville and Leesburg, degrittied sewage from the campus plant was substituted for the Leesburg sewage at the end of the first week. No problems were experienced.

Samples of citrus waste were obtained periodically from the head box at the new Leesburg wastewater treatment plant. Samples were collected in 13-gallon carboys, transported to Gainesville, and stored at 4°C. until used. The 50-50 mixture was made up daily.

On several occasions, the pH of the citrus waste was found to range as high as 12.0 to 12.6. After mixing with sewage, the pH was lowered to 7.0 plus or minus, by the addition of sulfuric acid. No attempt was made to raise the pH if it was on the acid side of the scale.

Results:

The biological floc developed without difficulty. No odors were experienced and the floc settled rapidly.

Test No. 2

Purpose: The determination of biological oxidation rates for citrus waste and a 50-50 mixture of domestic sewage and citrus waste.

Procedure:

A sample of Leesburg citrus waste was collected on December 10, 1966. Serial BOD dilutions were set up and incubated at 20°C. for 1, 2, 3, 4, 5, 6, and 12 days. The results were as follows:

Time (Days)	BOD (mg/l)	Calculated BOD Values $K_1 = -0.106 L_a = 1141$
0	0	0
1	95	246
2	472	442
3	(590)*	592
4	650	710
5	766	804
6	857	877
12	907	1081

*No dilution within range. Estimated.

Judging from the difference between the first and second day BODs, a significant lag appears. This is probably due to the fact that the citrus waste was seeded with normal domestic sewage and the sewage biota had to be acclimated to the citrus waste.

Using the slope method suggested by Thomas, values for K_1 and L_a were calculated and found to be as follows:

$$K_1 = 0.106$$

$$L_a = 1141 \text{ mg/l}$$

Using these values, the theoretical BOD values were calculated and included in the above table.

Samples of Leesburg citrus waste and Leesburg domestic sewage were collected on December 29, 1966. Serial dilutions were set up on a 50-50 mixture and incubated at 20°C. for 1, 2, 3, 4, 6, and 10 days. The results were as follows:

Time (Days)	BOD (mg/l)	Calculated BOD Values $K_1 = -0.101$ $L_a = 2438$
0	0	0
1	468	502
2	736	880
3	1446	1226
4	1544	1475
6	1792	1833
10	2312	2199

Using the slope method suggested by Thomas, K_1 and L_a values were calculated and found to be:

$$K_1 = -0.091$$

$$L_a = 2623$$

The graphical method suggested by Thomas and Tsiroglou's daily difference method were also used to calculate K_1 and L_a .

A summary of the values is given below:

Method	K_1	L_a
Thomas' Slope Method	0.091	2623
Thomas' Graphical Method	0.088	2644
Tsiroglou's Daily Difference Method	0.125	2048
Average	0.101	2438

Using the average values for K_1 and L_a , the theoretical BODs were calculated.

Test No. 3

Purpose: To determine the effects of various mixed liquor suspended solids (MLSS) concentrations on the removal of BOD and the buildup of sludge mass.

Procedure:

Four 15-liter containers were filled with 12 liters of a 50-50 mixture of Leesburg citrus waste and domestic sewage. Varying amounts of an acclimated biological floc were added to each unit and the units aerated for 24 hours. Samples were withdrawn from each unit at predetermined time intervals and the BOD and suspended solids determined. A summary of the results is given below:

Time Hours	Test A 250 ml		Test B 500 ml		Test C 1000 ml		Test D 1500 ml	
	BOD	MLSS	BOD	MLSS	BOD	MLSS	BOD	MLSS
0	1032	1084	1213	1208	899	1240	1088	1268
2	645	1150	599	1160	554	1310	511	1140
4	506	1200	500	1210	432	1290	410	1270
6	398	1180	373	1300	336	1290	329	1260
8	338	1180	286	1170	244	1220	224	1320
12	165	1020	122	1490	117	1340	61	1400
24	115	1110	102	1210	97	1310	79	1300

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SECTION 1

PURPOSE AND SCOPE

The purpose of this study was to investigate treatment of a relatively large quantity of weak citrus wastes from two processing plants; namely, The Coca-Cola Company Foods Division and Adams Packing Company, along with the treated effluent from the domestic waste treatment plant of the City of Auburndale. The investigation included loading parameters, evaluation of plant design, required nutrient levels, operational control parameters, and a study of the ecology of the raw waste stream, the entire treatment process, and finally, of the receiving stream. Kinetic studies and nutrient removal by aquatic plants were also included in this investigation.

Operational parameters such as minimum dissolved oxygen levels, excess sludge buildup, and sludge recirculation rates could not be fully investigated as previously anticipated due to the inadequacy of the sludge collection and return system. Because of this, the plant could not be effectively operated as an extended aeration plant and had to be converted to operate as an aerated lagoon system. The scope of this investigation was broadened to include design parameters to treat weak citrus wastes by means of an aerated lagoon system.

Further study objectives included the possible use of water hyacinths in cattle feed and the possible reuse of treated wastewater in the citrus processing plant.

Velocity distribution studies in the lagoons using Rhodamine-B dye as a tracer were unsuccessful due to adsorption of the dye by high solids concentrations in the lagoon system.

SECTION 2

GENERAL DESCRIPTION OF WASTEWATERS

2.01 THE COCA-COLA COMPANY FOODS DIVISION

Wastewater characteristics and sources are described generally in the Introduction to Part I of this report. Specific sources and characteristics of individual waste streams were not included in the scope of this investigation.

Project location and vicinity maps are shown in Figure 1 and Figure 2, respectively. Sources of wastewater at the Auburndale plant are shown in Figure 3a. Measurements of volumes and strengths of wastes from various processes within the plant will be begun by The Coca-Cola Company during the 1969-70 citrus processing season. Some investigative work to trace sources of overload throughout the study period indicated that wastes from feed mill, juice extractor, Hi C plant, and oil recovery processes contributed significantly to the total waste load. Some typical COD values from both The Coca-Cola Company and Adams Packing Company are exhibited in Appendix 1. These values were on grab samples taken during January and February, 1969, and are by no means to be construed to be typical for all process plants nor all operating conditions.

The citrus processing season at Auburndale usually extends from December through July, depending upon crop conditions. Processing is slackened or halted for a short period in March for the midseason changeover to later maturing fruit. During the changeover and off season the principal wastes are from the repacking, ades and bases, and beverage operations. The wastewater loadings and volumes during these operations are relatively light.

Wastewater from the concentrate plant is screened to remove peel, pulp, seeds, and other suspended material. Gross solids are also removed from wastewater from the fruit unloading and preparation operations and the barometric condensers. Unlike the Leesburg processing plant, the two wastewater streams are not segregated; therefore, the processing wastes yield large volumes of moderately low-strength wastewater.

Wastewater volume and strength vary considerably depending upon processing operations. Poor operation in the feed mill, pressed liquor and oil recovery systems have a detrimental effect on the biological treatment process. Peel oil is toxic and acts as a bacteriostatic agent, greatly affecting both the biological process and the major operational control parameter; namely, the BOD.

Variations in pH values are caused by discharges of caustic during cleanup operations. However, due to the large dilution, these variations are slight and pH values average about 7.0.

In general, the wastewaters are deficient in nitrogen and/or phosphate compounds required for optimum biological treatment.

Total citrus wastewater flow from The Coca-Cola Company at Auburndale is approximately 20 mgd. Biological and chemical oxygen demands are of the order of 120 mg/l and 210 mg/l, respectively. The wastewater is discharged into Lake Lena Run and the entire creek is taken into the wastewater treatment facility.

The citrus processing plant at Auburndale operates on a 24-hour per day basis during the crop season. Daily production levels during the 1968-1969 processing season averaged 50,000 boxes of fruit.

2.02 ADAMS PACKING COMPANY

Wastewater characteristics and sources from Adams are essentially the same as those of The Coca-Cola Company. However, in addition to the concentrate process, Adams includes wastewater from a sectioning operation in fruit processing and a single-strength operation in juice processing which produce about 3 mgd of wastewater and average COD values of the order of 500 mg/l. Sources of wastewater at the Adams Packing Company are shown in Figure 3b.

Adams' processing season at Auburndale usually extends from November through July with a brief slackening during midseason.

Wastewater from the concentrate plant, fruit unloading and preparation operations, and barometric condensers are not segregated. Gross solids are removed by screening prior to discharge into Lake Lena Run. The process yields large volumes of moderately low-strength wastewater deficient in nitrogen and/or phosphate compounds.

Wastewater volume and strength have the same degree of variability as those from The Coca-Cola Company and for the same general reasons.

Total wastewater flow from Adams at Auburndale is approximately 10 mgd. Biological and chemical oxygen demands are approximately 190 mg/l and 290 mg/l, respectively. pH values average about 7.0.

Adams' processing plant at Auburndale operates on a 24-hour per day basis during the principal crop season. In slack and off seasons principal wastes are from repackaging operations which yield relatively light flows and organic loadings. Daily production levels during the 1968-1969 processing season averaged 60,000 boxes of fruit.

2.03 CITY OF AUBURNDALE

The population of Auburndale in 1969 was 7,030. A population of 11,396 is expected by 1980. The economy of Auburndale is based almost entirely on the citrus processing industry.

The City of Auburndale sewage treatment plant receives waste from both domestic and industrial sources. The average daily flows are of the order of 762,650 gpd and influent BOD's average 225 mg/l.

Industrial wastes from certain manufacturing complexes contain appreciable amounts of formaldehyde and other toxic compounds. This greatly affects the efficiency of the biological process and adds an additional organic load and possibly toxic substances to the treatment plant effluent. Effluent from the domestic treatment plant is discharged through an 18-inch outfall extending 2,800 feet below the city treatment plant into Lake Lena Run above the citrus treatment plant. The effluent from the city treatment plant is included in the wastewater received by the citrus wastewater treatment facility.

The effluent wastewater exhibits BOD's of approximately 75 mg/l. The flow averages 762,500 gallons per day and contains appreciable quantities of both nitrogen and phosphate compounds.

SECTION 3

CITRUS WASTEWATER TREATMENT PLANT

3.01 GENERAL DESCRIPTION

The plant was designed for extended aeration of unclarified wastewater with completely mixed recycled sludge. Two shallow oxidation ponds (in series) were provided for further polishing of the effluent before discharge into Lake Lena Run. A schematic flow diagram is given in Figure 3.

The plant consists of four unlined, earthen ponds covering an area of approximately 23.6 acres. Citrus processing wastewaters (including the effluent from the City of Auburndale) are delivered, by gravity, to the treatment site by means of Lake Lena Run. A weir is provided below the treatment plant intake so that the entire run flows into the aeration pond. Flow rates exceeding 30 mgd (with 40 percent recirculation) overflow the weir and that portion of the flow bypasses the treatment plant. The aeration pond covers 3.15 acres, is 11.7 feet deep, has a capacity of 9.7 million gallons (MMG), and is equipped with six 75-horsepower floating mechanical aerators.^(a) A float control in the aeration pond activates each of three transfer pumps which lift the mixed liquor from the aeration pond to the second pond. The transfer pumps have a total pumping capacity of 42 mgd. Two pumps are equipped with 50 horsepower motors and one pump is equipped with a 30 horsepower motor. The two larger pumps each have a pumping capacity of 17 mgd and the smaller has a capacity of 8 mgd. The mixed liquor from the aeration pond flows through a vented 42-inch discharge line into a distribution trough in the second earthen pond. This pond serves as a clarifier and has a dual function; namely, sludge settling and collection. The settling and collection section of the pond covers approximately 2.72 acres, is 14.2 feet deep, and has a capacity of 9.2 MMG. The remainder of the pond covers 4.1 acres, is 9.7 feet deep, and has a capacity of 11.6 MMG. Sludge collection and recycling is accomplished by suction-type sludge pickups into a vented 36-inch gravity line back to the aeration pond.

Metering devices^(b) include Dall tubes (installed in both the 42-inch transfer line and the 36-inch gravity return sludge line), transmitters and continuous flow recorders with totalizers. Flow measurements on the 42-inch transfer line represent the total flow (plant influent and recirculated sludge); whereas those measurements on the 36-inch gravity line represent only the recirculated sludge. The daily plant influent is obtained by difference.

The effluent from the settling pond flows by gravity into a third earthen pond which serves as an oxidation pond. This pond covers 6.85 acres, is 5.0 feet deep, and has a capacity of 10.5 MMG. A fourth earthen pond (also an oxidation pond) is gravity fed from the third pond. An area of 6.85 acres is utilized with an average depth of 4.5 feet and a capacity of 9.5 MMG. The pond effluent is discharged, without chlorination, into Lake Lena Run.

^a Manufactured by Yeomans Brothers Company, Melrose Park, Ill.

^b Manufactured by B-I-F Division, Providence, R.I.

Flow control baffles were provided in each of the last three ponds to insure better mixing within each pond and to prevent short circuiting of the treated effluents.

Facilities were included for adding both aqua ammonia and phosphoric acid as supplemental nutrients. These are added to the mixed liquor in the aeration pond.

No provisions were made for wasting or treating waste sludge. Sludge carryover from the settling pond to the oxidation ponds will necessitate periodic dredging of one or both of these ponds.

A summary of wastewater pond characteristics is presented in Table 1.

3.02 STATISTICAL STUDY

Weirs, level recorders, and automatic sampling devices were installed at points indicated in Figure 2 to provide design data for Auburndale citrus wastewater treatment facilities. Weir No. 1 was located in Lake Lena Run below Adams Packing Company. Weir No. 2 was located at Recker Highway and included flows from Adams Packing Company, The Coca-Cola Company, and the City of Auburndale sewage treatment plant.

Flows were measured at the above described weirs throughout the 1966-67 citrus processing season, and the results are given in Table 2. Area precipitation during the season is described in Tables 2 and 3. Statistical analyses were made for flows at Weir No. 2 as shown in Figures 4, 5, and 6.

Organic loads (BOD) and nutrient levels at Weir No. 2 were analyzed statistically as shown in Figures 7, 8, and 9.

Composite samples were collected and analyzed routinely at each of the weirs during the first half of the 1966-67 processing season, and two samples were collected at Darby Avenue (Figure 2). Results of the analyses are given in Tables 4, 5, and 6.

3.03 DESIGN CRITERIA

Basic design of these facilities involves the activated sludge (extended aeration) process. Plant design criteria was partially based on a statistical study made during the 1966-67 citrus season. Design parameters were primarily based on a survey of the industry by Fiske and Gay.¹ They reported a combined volume from the two citrus processing plants of approximately 25.5 mgd with a combined organic loading (COD) of 29,500 pounds. Using the COD-BOD conversion factor suggested by McNary,² the 5-day, 20°C. BOD strength would be of the order of 18,500 pounds per day. Design hydraulic and BOD loadings of 30 mgd and 18,500 pounds per day, respectively, were assumed.

A relatively inexpensive settling basin^(c) was substituted for conventional clarifiers to minimize construction costs. Treatment units were arranged to permit wastewater transfer and sludge recirculation with a single, low cost pump station. The plant will accommodate hydraulic loadings of 30 mgd with an additional 40 percent of this flow as sludge recirculation.

Plant characteristics were as follows:

Plant influent, mgd:	
Average	15.6
Maximum	30.0
BOD concentration, mg/l	74
BOD loading, lbs/day	18,500
Recirculated sludge, mgd	12.0 - 26.4
Extended aeration:	
Mixed liquor suspended solids:	
Concentration, mg/l (ave)	2,300
Under aeration,	
lbs/lb BOD	10
Total plant area, acres	23.6
Total detention time, days (ave)	3.2

Further details of pond and treatment plant characteristics are described in Tables 7 and 8.

Actual data collected during the 1968-69 citrus processing season indicated substantial increases in the organic (BOD) loadings. This was due, in part, to unexpected changes in processing and increased production at both The Coca-Cola Company and Adams. Production levels during the 1969-1970 processing season increased by 10,000 boxes of fruit per day and are expected to increase yearly by the same for the next few years.

^c See Section 5.02, first paragraph.

SECTION 4

PLAN OF INVESTIGATION

4.01 GENERAL

Principal objectives of plant operation during the 1968-69 citrus processing season were to demonstrate capabilities of the low cost plant and to determine favorable operating procedures.

The general plan of experimentation involved the variables that were subject to operational control. These were loading, nutrient level, and sludge recirculation rate. It was planned to change one of these variables at a time, under optimum conditions, in a series of tests covering the 1968-69 citrus processing season. However, despite a wide variety of operating procedures, the mixed liquor suspended solids (MLSS) concentration could not be increased above about 200 mg/l. It was concluded prior to midseason that the settling basin did not afford MLSS control because of an inadequate sludge collection system. Due to this inadequacy, the plan of investigation had to be altered somewhat from the original plan since the system was operating as an aerated lagoon system rather than an activated sludge system. Sludge recirculation rates were maintained at 100 percent of the influent flow and the only control variables were hydraulic loadings and nutrient levels.

Supplementary routine analyses for nitrogen and phosphorous concentrations in the wastewater and pond effluents were made.

Kinetic studies were performed to determine BOD removal rate coefficients and temperature coefficients which are necessary in order to design an aerated lagoon system (see Appendix 5).

Experimentation included an ecological study throughout the treatment system and also the use of aquatic plants (hyacinths) for nutrient removal. Aquatic plants were further studied for nutritional value and possible use in cattle feed.

4.02. SAMPLING PROCEDURES

Routine sampling of the combined citrus wastewater flow was accomplished by means of a Chicago Pump Company "Tru-Test" sampler. Effluent flows from the settling pond and Polishing Pond No. 2 were collected routinely by means of portable automatic samplers. Locations of the sampling stations are indicated in Figure 3. Samples were collected over 24-hour periods in polyethylene containers. Those samples collected in the "Tru-Test" sampler were maintained at 40° F. in the refrigerated compartment of the sampler throughout the 24-hour period. Other samples were kept packed in ice in a polystyrene cooler throughout the same sampling period.

Grab samples were taken from the aeration pond effluent, Polishing Pond No. 1 effluent, and recirculated sludge return line once each 24-hour shift. Plant influent grab samples were analyzed once each 8-hour shift for COD concentrations.

Automatic samplers, although convenient, do not take truly representative samples due to the stringy solids in the waste. On several occasions analyses were made on grab and automatic samples collected simultaneously. BOD, COD, and suspended solids results generally were higher on the grab samples by 10 to 20 percent. However, all data presented in this report were based on the automatic sampling procedures described in the preceding paragraphs. Since the data are consistent, all efficiencies (ratios) are only slightly affected; influent data may be slightly low.

4.03 TESTING PROCEDURES

All testing procedures were in accordance with "Standard Methods for Examination of Water and Wastewater," 12th Edition, APHA, AWWA, WPCF (1965).

Routine sampling and testing were accomplished by the operating personnel of The Coca-Cola Company Foods Division wastewater treatment plant. A summary of the tests conducted at the plant is shown in Figure 11. Training and supervision were provided by Black, Crow and Eidsness, Inc.

Weekly composite samples of the plant influent, settling pond effluent, and Polishing Pond No. 2 effluent were analyzed for forms of nitrogen and total phosphates. These samples were preserved with mercuric chloride to prevent changes in the nitrogen balance due to further biological activity. Nitrogen and phosphorous determinations were made by Black, Crow and Eidsness personnel on a Technicon AutoAnalyzer, Gainesville, Florida. Samples were transported to the laboratory within 24 hours after collection.

SECTION 5

PLANT OPERATION

5.01. CITRUS PROCESSING SEASON, 1968-69

Plant construction was completed November, 1968. Processing wastes from Adams and The Coca-Cola Company were received on November 14 and December 2, 1968, respectively. Although citrus processing wastes were received and a detailed sampling program initiated at the start of the 1968-69 season, the treatment plant facilities were not fully operative until January 15, 1969. Between January 17 and 20, 1969, 60,000 gallons of waste activated sludge from the Leesburg plant were added to the aeration pond in an effort to rapidly build up the mixed liquor suspended solids (MLSS). However, despite a wide variety of operating procedures, the MLSS concentration could not be increased above 200 mg/l. It was concluded in February that the sludge collection system was inadequate and that existing treatment facilities could not be operated as an extended aeration system. BOD removals between December, 1968, and February, 1969, averaged about 62 percent and MLSS concentrations averaged 67 mg/l. See Table 16 for average weekly operating data.

Hydraulic loads during the outset of the processing season were about one-half the design capacity; however, organic loadings (BOD) were almost twice those anticipated.

During March, 1969, the treatment plant was set up to operate as an aerated lagoon system as described in "Industrial Water Pollution Control" by W.W. Eckenfelder.³ The principal objectives during the remainder of the processing season were to determine optimum operating conditions and to collect pertinent background data required for design of an aerated lagoon system.

The Coca-Cola Company halted operations on March 3, 1969, for the mid-season changeover to Valencias and resumed operations April 15, 1969.

Reasonable control was maintained over influent flows and recirculation rates during the last phase of the research program. Influent flow rates were maintained at approximately 5 mgd from May 1 through May 19, and at approximately 10 mgd from May 20 through June 13, 1969. Recirculation rates averaged 4.8 mgd and 10.4 mgd, respectively, during these periods. BOD removals averaged 94.5 percent and 83.8 percent, respectively, at the 5 mgd and 10 mgd influent flow rates.

Nitrogen levels in the raw wastewaters were low and were supplemented by the addition of aqua ammonia. BOD:N ratios during the processing season averaged about 20:1, which is higher than the 30:1 BOD:N ratio recommended by Helmers in a paper by Eckenfelder.⁴ Phosphorous levels in the raw wastewater were variable and when necessary were supplemented by the addition of phosphoric acid. BOD:P ratios averaged 103:1 for the entire study period and 148:1 and 99:1, respectively, during the 5 mgd and 10 mgd controlled flow period. These values compare to phosphate levels recommended in the literature as being adequate for optimum biological activity. It appears that the supplemental nutrients are required to promote favorable growth conditions at the startup

of a biological system and become of lesser importance once the system is acclimated. Phosphorus appeared least important after startup, since supplemental phosphorus was omitted for long periods of time with little or no change noted in BOD removals. A BOD:N:P ratio of 150:5:1 appears to be applicable to citrus wastes.

5.02 PROBLEMS ENCOUNTERED

The major problem was the failure of the sludge collection system to collect sludge, making it impossible to study the design concept involving the extended aeration process. The sludge collection area was too large and the slopes were too gentle to effectively move the sludge to the gravity pickups. (A minimum slope of approximately 60° is suggested, whereas the slope in the sludge collection section of the settling pond was only about 15°.) Mechanical scrapers may have aided the collection procedure; however, due to the size scrapers required, the cost would have been substantial.

Minor difficulties were encountered in the metering transmission system on the transfer lines between the aeration pond and Pond No. 2 (settling pond). This was caused by air trapped in the transmission system.

Other inadequacies in plant equipment were found in the flow metering system, transfer pumps, and flotation devices on the mechanical aerators. The low cost metering system was provided to cover a range of between 5 and 50 mgd and still deliver reasonable accuracy. However, the Dall tube designed for this flow range operates at subatmospheric pressures (negative head) at this installation when two or more pumps are operating. This is not a serious problem so long as the pressure piping from the flow tube to the transmitter is airtight. Air trapped in the transmitter lines could lead to minor metering inaccuracies. Daily manual venting of the air bleed-off valves is recommended.

High volume, low head lift pumps of the type used in irrigation of citrus groves were used to provide a low cost lift station to transfer the mixed liquor from the aeration pond to the higher elevation of the settling pond. This provided a means for gravity sludge recirculation, thereby eliminating a second pumping station. The lift pumps are extremely sensitive to small head variations and when all three pumps are operating simultaneously, the discharge rates are somewhat lower than the rated capacities indicated by the pump discharge curves.

Only three of the six floating mechanical aerators were operative when plant operation began in November-December, 1968, due to a design fault in the flotation devices. The fourth aerator was placed in service on December 21, 1968, and the fifth and sixth aerators were in service by January 15, 1969. In repairing the flotation devices, buoyancy was increased and it was May, 1969, before aerators could be operated at maximum efficiency.

The fiber glass flotation devices were not properly tested by the manufacturer prior to delivery to the plant site. Although similar flotation units equipped with smaller aerators have been successful at other installations, starting the 75 horsepower aerators created significantly more stress than the fiber glass floats could withstand. Consequently,

small fatigue cracks developed at points of excessive stress and the floats were no longer watertight. The level of submergence was adversely affected and the flotation units had to be removed from the system and repaired by reinforcing and filling the floats with bouyant material. Unless significant changes in design are made on the fiber glass floats, steel floats with positive flotation are recommended for future installations involving aerators exceeding 60 horsepower.

Earthern aeration basins should be provided with concrete pads or some sort of stabilizing material below the mechanical aerators. Poor mixing in the aeration basin was noted during March, 1969. Investigation of the problem revealed that turbulence from the mechanical aerators had dug holes approximately eight feet in depth below the bottom level of the aeration basin, greatly affecting mixing patterns.

Several thousands of gallons (approximately 3,500) of pressed liquor (toxic) from Adams and excessive feed mill wastes (high BOD) from both Adams and The Coca-Cola Company were discharged into Lake Lena Run and subsequently taken into the waste treatment plant on January 3 and 4, and again on January 6, 1969. This material grossly overloaded the system. With only four aerators in operation, the required volume of air for proper treatment could not be supplied. Consequently, the entire system of ponds developed anaerobic conditions and had to be drained on January 11, 1969.

It is apparent from this study that a generous variety of problems are inherent during the first year's operation of a new waste treatment facility. Mechanical equipment requires frequent adjustment and plant operators in many cases are not familiar with the plant's capabilities nor the degree of variability of the wastewater. Therefore, detailed research, plant design, and capability evaluations should not be initiated until plant operations are stable and operators have a thorough knowledge of the treatment process and waste characteristics.

SECTION 6

HYACINTH STUDY

6.01 GENERAL

The purpose of this study was to examine nutrient uptake by water hyacinths and to investigate the possible use of these plants in cattle feed.

A hyacinth pond with a total surface area of 1,130 square feet, an average depth of six feet, and a total volume of 50,850 gallons was constructed of plywood and lined with plastic in Polishing Pond No. 1. Influent to the water hyacinth pond was pumped from the effluent from the settling pond. Influent 5-day BOD's ranged from 22 mg/l to 56 mg/l during the period of this study. Nitrogen and phosphorous concentrations were well above those recommended as being sufficient for bio-oxidation. Average total nitrogen concentration ranged from 3.58 mg/l to 5.27 mg/l, and average phosphorous concentrations ranged from 0.75 mg/l to 0.76 mg/l.

Hyacinths were harvested from Lake Parker, Lakeland, Florida, and a total of 850 pounds of plants were placed in the hyacinth pond at Auburndale on April 22, 1969. The plants loosely covered an area of 660 square feet out of a total pond area of 1,130 square feet. Plant root lengths ranged from 6 to 16 inches and averaged 8 inches. The hyacinth plants were acclimatized for a one-week period prior to experimentation. The investigative period extended from April 30 through June 30, 1969.

Penfound and Earle⁵ conducted studies on hyacinth plants in New Orleans, Louisiana. They determined that the wet weight of hyacinth plants varied from 120 to 180 tons per acre and would yield 7 to 10 tons of dry plant material. Rate of propagation was also studied and they concluded that ten plants would cover an area of one acre in one growing season. Our study confirmed this propagation rate since after a one-week period each plant had produced three new plants. Penfound and Earle further determined that hyacinths could withstand temperatures of 33°F. for periods of 12 hours with slight leaf damage; however, 24-hour exposures at 20°F. killed the plants. Temperatures seldom range below 33°F. at Auburndale for extended periods; therefore, environmental conditions are ideal for a long growing season. Other observations by Penfound and Earle were that oxygen levels below dense mats of hyacinths were less than 0.1 mg/l; under closely growing plants but without a mat, dissolved oxygen concentrations were 0.5 mg/l; where only 80 percent of the total surface area was covered, dissolved oxygen levels averaged about 1.5 mg/l.

6.02 NUTRIENT UPTAKE

The first phase of study extended from April 30, 1969, through May 28, 1969. A 2.4-day detention time with continuous flow conditions was employed. Plant root lengths at the influent end of the hyacinth pond averaged 12 inches, whereas the roots at the effluent end remained approximately 8 inches long. A slime covered the roots of the plants at the influent portion of the pond but was absent from those at the effluent end. Dissolved

oxygen concentrations in the influent and effluent hyacinth pond streams averaged 1.9 mg/l and 1.0 mg/l, respectively. Chemical oxygen demand (COD) reductions averaged 29.9 percent and biological oxygen demand (BOD) reductions averaged 45.2 percent. Organic nitrogen exhibited reductions of 25.8 percent and little or no changes were observed in the remaining forms of nitrogen. Phosphate reductions averaged 14.7 percent. A summary of the 2.4-day detention period data is given in Table 9.

The last phase of investigation covered the period June 2 through June 30, 1969. A 5-day detention time with continuous flow conditions was employed. Little change was observed in root lengths during this period of study. Microbiota attached to the hyacinth roots at the influent portion of the hyacinth pond were studied. Several forms of bacteria, blue-green algae, green algae, volvocales, zooflagellates, and ciliates were found. These organisms account for the substantial biological purification observed across the hyacinth pond. A summary of microbiota found on the hyacinth plant roots and in the influent and effluent streams of the hyacinth pond are exhibited in Table 10. Dissolved oxygen concentrations did not deplete as expected due to the fact that we only had approximately 72 percent of the total surface area covered. Dissolved oxygen levels averaged 1.24 mg/l in the influent stream and 1.00 mg/l in the effluent stream. This agrees with the work done at Louisiana, since Penfound and Earle reported oxygen levels of 1.5 mg/l with approximately 80 percent of the water's surface covered by plants. An area of 36 square feet of hyacinths yielded a wet weight of 140 pounds. This is equivalent to 86 tons of hyacinths per acre and further indicates that a dense growth had not been attained since Penfound and Earle commonly found 120 to 180 tons of hyacinth plants per acre. Biological and chemical oxygen demands were reduced by 69.6 and 47.2 percent, respectively, during this study period. Organic nitrogen decreased by 59.9 percent and ammonia nitrogen increased by 411 percent. Slight reductions in both nitrite and nitrate nitrogens were observed. Decreases in organic nitrogen are attributed to the increased biomass on the roots and the sharp decrease in suspended solids. An increase in ammonia nitrogen is contrary to the findings of Clock.⁶ Although the pressed liquor analyses indicate a greater uptake of ammonia nitrogen (Table 12) during the 5-day detention period, apparently the denitrification process released more nitrogen as ammonia than the plants could utilize at this detention time. Overall nitrogen reductions were only slightly higher than at the 2.4-day detention time. Phosphate reductions were substantially better at the longer detention periods as 35.5 percent of the phosphate was removed, compared to 14.7 percent at the 2.4-day detention period. Table 11 summarizes the 5-day detention period data.

Based on the above data, the following conclusions were reached:

1. A minimum of 5 days' detention would be required to obtain significant nutrient reductions.
2. Since the average total detention time in the polishing ponds is only 42 hours, nutrient removal by hyacinths in the present facility is not applicable.
3. Biological and chemical oxygen demand reductions by the hyacinth plant system appear to be more promising than nutrient removals.

Furman and Gilcreas⁷ reported serious mosquito breeding problems in a study near Tampa, Florida, when hyacinths formed dense mats over the water's surface. This was not found to be a serious problem at Auburndale, however, our hyacinth pond was relatively small compared to the lagoon system studied by Furman and Gilcreas.

6.03 HYACINTH PLANT CHARACTERISTICS

Detailed chemical analyses were made on the hyacinth plants at the outset of this investigation, during the 2.4-day detention period, and during the 5-day detention period. Air dried samples averaged 95 percent moisture throughout the study period. Protein and ash concentrations increased significantly with detention time, whereas crude fiber concentrations remained virtually unchanged. Results of these analyses are shown below.

Constituent	Average	Analyses ¹	
	Hyacinth Plants Natural State	2 - Day Detention	5 - Day Detention
Moisture, percent ²	95.0	95.0	95.0
Protein, percent	12.26	11.00	19.90
Ash, percent	13.75	16.00	16.80
Crude fiber, percent	15.12	12.05	16.93
Ether extract, percent	1.99	2.09	1.14
Carotene, mg/lb	-	0 - 28	21.6
Xanthophyll, mg/lb	-	70	304
Dicumarol, mg/lb	-	35	-
KNO ₃ , g/g	649	505	367
Oxalate, mg/g	-	0.4	-
Total PO ₄ - P, mg/g	0.65	7.0	7.7
Total N, mg/g	-	112.0	55.8

¹Analyses were made by personnel of University of Florida, Animal Nutrition Laboratory and personnel of The Coca-Cola Company, Foods Division Research Laboratory.

²Moisture on air dried samples at 103°C. averaged 10 percent.

Chemical analyses of Alfalfa hay exhibit characteristics similar to the dried hyacinth plants. Protein values average 15 percent, fiber 28 percent, and moisture about 9 percent. Bahai grasses average 10 percent protein and 5 percent ash. Based on these comparative analyses, dried hyacinth plants have good potential as a supplemental feed for cattle.

An attempt was made to process the hyacinth plants through the existing feed mill facilities at Auburndale; however, due to the fibrous nature of the hyacinth plant, fouling of equipment was encountered. It was concluded that hyacinth plants would require special processing equipment and that present feed mill facilities were inadequate to process the plants without some capital improvements.

Harvesting of the hyacinth plants could be accomplished on a large scale operation by means of several mechanical devices now available for aquatic vegetation control. Harvesting operations during this study were done manually.

6.04 PRESSED LIQUOR

Pressed liquor analyses indicate that significant quantities of nutrient are released during processing. A summary of pressed liquor analyses is given in Table 12. Nitrogen and phosphorous concentrations in the pressed liquor increase with detention time. Also, the volume of wastewater from the squeezing process is considerable.

Based on an average wet weight of 150 tons of plants per acre, of which approximately 95 percent is water, 34,000 gallons per acre of additional wastewater would be produced. Assuming an average $\text{PO}_4\text{-P}$ concentration of 63 mg/l and an average total-N concentration of 335 mg/l in the pressed liquor, this amounts to an additional 18 pounds per acre and 95 pounds per acre, respectively, of phosphorus and nitrogen in the wastewater stream. Citrus wastewater flows would be increased by some 0.1 percent per acre of plants processed; however, nitrogen and phosphorous concentrations would be increased significantly in the normally nutrient deficient process water. During periods of hyacinth plant processing a small savings in chemical costs for supplemental nutrient would be realized.

SECTION 7

ECOLOGICAL STUDY

7.01 GENERAL

A detailed ecological survey was made by Dr. James B. Lackey of the Auburndale wastewater treatment plant to characterize types of biota associated with the treatment process. Auburndale facilities had recently been converted to operate as an aerated lagoon system and had not stabilized by the time of the first survey. A second study was made at Auburndale after three months' operation as an aerated lagoon system.

7.02. AUBURNDALE AERATED LAGOON SYSTEM

No previous background data were available for the Auburndale treatment plant. At the first visit conditions throughout the plant were not satisfactory, although BOD removals averaged about 70 percent. The principal objection was odor. Since the treatment plant effluent discharges into Lake Lena Run which terminates at Lake Hamilton, widespread odors could be considered a nuisance and improper treatment could be detrimental to the lake. Vast improvement was noted on the second visit as BOD removals averaged better than 80 percent and there were no objectionable odors.

Microbiota at Auburndale were first studied on March 11, 1969. The ponds were turbid, but not colored. The mixed liquor in the aeration pond did not contain as a great a quantity of organisms as found at Leesburg, but the biota was roughly the same. A qualitative examination of the biota in the aeration pond indicated a nontoxic, high organic content, low carbon, high nitrogen, and high phosphate substrate with a BOD high enough to be putrescible if not sufficiently mineralized. The high nitrogen and phosphate were due to supplementary nutrients added as aqua ammonia and phosphoric acid at a BOD:N:P ratio of roughly 150:5:1.

Some of the organisms were attached to roots or the sides of the aeration pond. These were filamentous green algae such as *Ulothrix*, *Schizomeris*, and *Rhizoclonum*, probably *Stigeoclonium* as well, and several worms, noticeably chironomid larvae. *Sphaerotilus* was the dominant organism in the mixed liquor (substrate). Colonies of *Zooglea* were abundant and the numbers of free swimming bacteria seemed low. Nevertheless, large numbers of Rotifera, Vorticellids, and Ciliates indicated a good food supply. *Beggiatoa* and large numbers of a *Spirillum* further indicated a low oxygen content. In addition, photosynthetic algae such as *Navicula*, *Ankistrodesmus*, and *Euglena* were present.

The concentration of oxygen in the first polishing pond was low, but nutrient conditions excellent as evidenced by the large variety of organisms shown in Table 1.3. The low oxygen is indicated by *Trepomonas*, *Saprodinium*, and various facultative organisms such as *Spirillum* and *Paramecium calkinsi*. Ciliates, *Oicomonas*, and Rotifera are bacterial

consumers. Blue-green algae, the colorless euglenids *Peranema*, *Sphenomonas*, and *Spondymonum* indicate soluble organic matter, while the various green algae add oxygen and utilize nitrogen and phosphorous. The second polishing pond was much the same, microbiota was varied, and there were indications that oxygen concentrations were low. Of particular interest was that seven green euglenids and *Spondylomorum* were numerous; in fact, so numerous as to constitute a bloom. Such a bloom of these organisms is prima facie evidence of recent organic contamination, usually fecal. This was probably due to the large numbers of egrets and other birds that congregate on the flow control baffles and berms of the polishing pond.

Conditions in Lake Lena Run, downstream from the treatment plant, further indicate the variety of microbiota in the treatment process. Here, all the organisms found in the treatment and others were present. At a point about 1.75 miles downstream, there was a heavy white coating of the colonial vorticellid *Zoothamnium* on every stick or other solid in the stream. These were dominant and could be seen from several yards away. In the stream the colorless flagellate *Monas* was dominant. It is also a consumer of bacteria, but ciliates were also present in large numbers. Blue-green algae, diatoms, green algae, many euglenids, desmids (a whole collection of typical stagnant water organisms) were present, such as are found in a relatively fertile situation.

A sample of unpolluted water from Saddle Creek was also examined at this time. This sample showed more varied diatoms, euglenids, volvocales, and desmids. The only group present here and lacking in Lake Lena Run was the Cryptophyceae.

A second ecological survey was made on June 11, 1969. Conditions were somewhat more favorable. Lake Lena Run above the waste treatment plant revealed considerable numbers of recently dead organisms. Either oxygen depletion or a slug of toxic material was implicated. The fact that two green organisms were alive, although few in number, and that some tolerant flagellates were present in the sludge supports this idea.

Substantial numbers of green organisms, as well as bacteria-consuming ciliates, were present in the aeration pond. A bloom had already developed of two photosynthetic algae, namely, *Ankistrodesmus falcatus* and *Chlorella* sp.

A steady improvement was noted throughout the plant until the bridge about one mile below the treatment plant outfall. Here the temperature was 36°C. and dissolved oxygen was only 0.5 mg/l. This was due to intentional bypassing of part of the untreated wastewater in order to maintain a controlled influent flow of 10 mgd for a phase of research in progress at the time of this survey. This caused a noticeable decrease in the number of bacteria, yeasts, and phycomycetes downstream as seen in Table 13.

The diversity of species was greater and green algae had assumed greater prominence since the first visit. The odor, prevalent on the first visit, had diminished. The stream's appearance toward Lake Hamilton was good.

Table 13 summarizes the data from both visits. In addition to the large number of genera and species present, the organisms found were quite similar to those of a well functioning domestic treatment plant. The waste was fairly well balanced nutritionwise. The

initial steps in decomposition produce large numbers of bacteria and related organisms. These, in turn, support a good population of colorless flagellates and ciliates. Euglenophyceas and Volvocales in the later stations, utilize the partially degraded organic matter and release enough inorganic nutrients to support a green population, useful in reaeration.

A buildup of sludge in the bottom of the polishing ponds at Leesburg and Auburndale could result in anaerobic conditions leading to odors and an increasing rise, due to gassing, with more solids going out in the effluent. It is suggested that these ponds be taken out of service periodically, the sludge dried and removed before the pond is put back in service. This may be necessary as often as every other year, depending on treatment practices.

SECTION 8

KINETIC STUDY

8.01 GENERAL

Kinetic studies were performed as described by Eckenfelder³ using an acclimated sludge at various temperatures, with and without nutrients. The purpose of these studies was to determine BOD removal rate coefficients and temperature coefficients (Appendix 5). These values are necessary in order to calculate design parameters for an aerated lagoon system. BOD removal rates exhibited a retardant-type reaction where removal rates decreased with time and concentration. A typical removal rate curve is presented in Figure 10.

8.02 LABORATORY STUDY

Studies were conducted at Auburndale during May and June, 1969. BOD removal rates were determined simultaneously at 20°C. and 25°C., with and without nutrients. Supplemental nutrients were added as ammonium hydroxide and phosphoric acid; concentrations were 5 mg/l $\text{NH}_3\text{-N}$ and 1 mg/l $\text{PO}_4\text{-P}$. Mixed liquor suspended solids (MLSS) concentrations ranged from 160 mg/l to 220 mg/l. The results of these studies are summarized as follows:

	BOD Removal Rate Coefficient - $k_{20^\circ\text{C.}}$	Temperature Coefficient - θ
Average	1.46	1.05
Maximum	2.80	1.06
Minimum	0.80	1.04

Variations of the BOD removal rate coefficients were caused by discharges of pressed liquor into the plant effluent, which is toxic and decreases the biological activity of the activated sludge. Also, the concentration of mixed liquor suspended solids affects the removal rate.

A study by Furman during the 1966-67 citrus processing season at Leesburg reported a BOD removal rate coefficient ($k_{20^\circ\text{C.}}$) of 2.86. Sample calculations of Auburndale and Leesburg data are presented in Appendices 2 - 4.

SECTION 9

RESULTS

9.01 GENERAL

Although the 1968-69 citrus processing season extended from November 14, 1968, through July 25, 1969, only those data collected between December, 1968, and June, 1969, were reviewed for purposes of this investigation. Citrus wastewaters received in November, 1968, and July, 1969, were principally from sporadic processing operations and not representative of wastewaters received during the main processing season.

Citrus processing wastewaters were bypassed on several occasions during the period of this investigation. Prior to January 15, 1969, intentional bypassing was employed in order to maintain aerobic conditions throughout the treatment plant, as only a portion of the aeration equipment was operative. During the period May 1 through June 13, 1969, investigations concerning plant capabilities required that influent flow rates be controlled at 5 mgd and 10 mgd. Therefore, a significant quantity of the wastewater stream was again intentionally bypassed. Thus, average hydraulic and organic loading values, as shown in this report, are somewhat lower than actual full-scale operating conditions.

Table 14 summarizes the average weekly data for the 1968-69 processing season presented in the forthcoming sections.

9.02 HYDRAULIC LOADINGS

Flow measurements were made by Dall tubes as indicated in Figure 3. These were installed with B-I-F instrumentation to indicate, record, and totalize flows from the aeration pond (total) and recirculated sludge line. Daily influent wastewater flows were obtained by difference.

Daily total flows ranged from 11.3 to 31.9 mgd and averaged 20.3 mgd. These data included daily influent wastewater flows which ranged from 5.5 to 20.5 mgd and averaged 12.8 mgd, and recirculated sludge flows which ranged from 2.4 to 13.2 mgd and averaged 7.5 mgd.

9.03 ORGANIC LOADINGS

Since citrus wastewaters contain substances which, at times, are bacteriostatic, both BOD and COD determinations were made in order to obtain comparative organic loading values.

Daily BOD loadings ranged from 3,432 to 22,099 pounds per day and averaged 12,256 pounds per day. Citrus processing wastewater 5-day BOD values ranged from 43 mg/l to 201 mg/l and averaged 117 mg/l. Daily COD loadings ranged from 8,021 to 52,516 pounds per day and averaged 20,756 pounds per day. COD concentrations in the influent stream ranged from 99 mg/l to 297 mg/l and averaged 190 mg/l.

9.04 COD/BOD RATIOS

COD/BOD ratios varied from 1.30 to 2.40 and averaged 1.73 on the untreated citrus processing wastewater (plant influent) and from 1.43 to 6.50 with an average of 3.34 on the wastewater treatment plant effluent during the study period.

9.05 BOD AND COD REMOVALS

Organic removal was somewhat lower than anticipated due to an inadequate sludge collection system which prevented operating the treatment facility as an extended aeration plant. BOD removals between December, 1968, and February, 1969, ranged from 6.7 to 85.5 percent and averaged 61.8 percent. COD removals were lower and ranged from 14.1 percent to 76.1 percent and averaged 46.7 percent for the 13-week period.

During March the operation was changed to explore the aerated lagoon process. Controlled flow conditions during May, 1969, and June, 1969, yielded average BOD removals of 94.5 percent and 83.8 percent, respectively. COD removals during the same period averaged 76.9 percent and 64.6 percent, respectively.

BOD removals for the entire 1968-69 citrus processing season ranged from 6.7 to 95.3 percent and averaged 70.8 percent. COD removals for the study period ranged from 14.1 percent to 79.4 percent and averaged 53.0 percent.

9.06 SUSPENDED SOLIDS

Suspended solids concentrations in both the influent stream and treatment plant effluent ranged from 0 mg/l to 120 mg/l and averaged 27 mg/l.

9.07 DISSOLVED OXYGEN

Dissolved oxygen concentrations in the aeration pond ranged from 2.0 to 6.8 mg/l and averaged 4.3 mg/l. Settling pond (Pond No. 2) dissolved oxygen concentrations ranged from 0 to 2.6 mg/l and averaged 1.3 mg/l. Polishing pond dissolved oxygen concentrations for the study period ranged from 0 to 5.7 mg/l and averaged 1.5 mg/l.

9.08 TEMPERATURE AND pH VALUES

Influent temperature and pH values averaged 27.4°C. and 7.1, respectively. Variations in temperature were $\pm 6^{\circ}\text{C}$. and pH variations were ± 0.2 . Effluent temperatures were affected by climatological conditions and ranged from 19.5°C. to 30.4°C. and averaged 23.6°C. Effluent stream pH values ranged from 7.1 to 7.7 and averaged 7.2.

9.09 NUTRIENT REMOVALS

Nitrogen and phosphorous determinations were made on the influent wastewater stream once each week to determine if nutrient concentrations were ample for biological treatment. Supplemental nitrogen and phosphorus were added to maintain desired nutrient levels. Effluent wastewaters were likewise analyzed to determine the reduction in nitrogen and phosphorous concentrations during bio-oxidation of the citrus processing wastewaters. Reductions were based on dosed influent nitrogen and phosphorous concentration levels.

Influent nitrogen concentrations (undosed) (Table 14) ranged from 1.60 to 5.64 mg/l and averaged 3.05 mg/l, whereas effluent concentrations varied from 2.01 to 5.12 mg/l and averaged 3.63 mg/l. Overall nitrogen removals for the study period averaged 36 percent and ranged from 0 to 70 percent.

Phosphorous concentrations (undosed) (Table 14) ranged between 0.21 and 1.84 mg/l and averaged 0.81 mg/l on the influent stream. Effluent stream phosphorous concentrations varied from 0.58 to 1.88 mg/l and averaged 1.16 mg/l. Phosphate removals for the 1968-69 citrus season ranged from 0 to 82 percent and averaged 37 percent.

9.10 REUSE OF TREATMENT PLANT EFFLUENTS IN CITRUS PROCESSING PLANT

Water uses at the Auburndale citrus processing plant include (1) process; (2) cooling; and (3) steam generation. Process water must be of potable quality, cooling water can be of a lower quality, and water for steam generation must have low hardness and other special requirements.

Analyses of the wastewater treatment plant effluent during the 1968-69 citrus processing season are exhibited in Table 14, indicating a potential for reuse as cooling water.

SECTION 10

DISCUSSION OF RESULTS

10.01 HYDRAULIC LOADINGS

Average flow measurements of 12.8 mgd as shown in Table 14 are lower than actual, due to intentional bypassing of a portion of the wastewater stream for control and research purposes. Observations during the study period indicated that average flows would approach 25-30 mgd when both The Coca-Cola Company and Adams were in full production. Studies made prior to and during the 1966-67 citrus processing season further support this idea. Fiske and Gay reported an average flow from both plants of 25.5 mgd and our statistical studies indicated average flows of 17.9 mgd.

Results from the controlled flow experiments shown in Tables 16 and 17 and design characteristics shown in Table 15 indicate that the present facility operating as an aerated lagoon system would accommodate wastewater flows of 6.4 mgd and achieve 91.3 percent BOD removal.

Production levels during the 1968-69 season from both citrus processing plants were approximately 110,000 boxes per day. Projected production levels for the 1969-70 season approach 135,000 boxes per day. Unless wastewater volumes are reduced in the processing plants, it is conceivable that wastewater flows during the next processing season will average in excess of 36 mgd.

10.02 ORGANIC LOADINGS AND REMOVALS

Many of the organic loadings reported were artificially reduced in order to study plant capabilities at lower influent flow rates. The average organic loadings passed through the treatment plant are consequently somewhat lower than the output of the citrus processing plants.

Based on flow data and 5-day BOD values obtained during full production, BOD loadings of the order of 32,500 pounds per day are anticipated during the 1969-70 citrus processing season.

A detailed summary of average monthly operations is presented in Table 18. Data for the month of May indicate that BOD loadings of 287 pounds per day per acre (6,789 pounds BOD per day) are optimum for the present facility. Based on kinetic data collected during this study and projected requirements for the 1969-70 processing season, an additional 40 acres of aeration space are necessary in order to operate the present facility as an aerated lagoon system and to obtain the required 90 percent BOD removal (see Section 11). To operate the facility as an extended aeration plant, two 200-foot diameter clarifiers and waste sludge handling facilities are needed using design criteria set forth in Section 12.

BOD reductions of the order of 57.3 percent were afforded through the aeration pond and the settling pond during the 1968-69 processing season. Additional aeration in the settling pond might increase BOD reductions by 5 percent; however, detention time is a major limiting factor in an aerated lagoon system as seen from data summarized in Table 18. The polishing ponds contributed significantly to overall BOD reductions during the study period. BOD removals through the polishing ponds averaged 13.5 percent as shown in Table 14. Operating the existing facility as an aerated lagoon system, with additional aeration in the settling pond and with hydraulic and BOD loading levels as indicated by this study, a maximum BOD removal of 75 percent would be estimated.

10.03 COD/BOD RATIOS

Weekly and monthly average COD/BOD ratios were determined and are exhibited in Tables 14 and 18, respectively. The small differences between the average values is due to the fact that the monthly averages tend to level out extreme variations more readily than weekly averages.

COD analyses were performed at the outset of the 1968-69 processing season. Refluxing times were varied from 10 minutes to 2 hours to determine maximum COD recovery. Since citrus wastes consist primarily of carbohydrates, they are susceptible to rapid oxidation. Reflux times of 20 minutes afforded better than 98 percent of the COD value obtained after two hours' refluxing; therefore, routine COD analyses were refluxed for a period of 30 minutes to minimize error. COD/BOD ratios of the citrus processing wastewater at Auburndale averaged 1.76. McNary² reported an average value of 1.56 during a pilot plant study.

The COD test plays a significant role in plant operations since organic loadings can be determined quickly and treatment operations adjusted accordingly. BOD analyses are not suitable for this purpose because of the 5-day time period required to obtain the results.

Another important factor concerning the COD test is that certain wastes from the citrus process are toxic and tend to give misleading (low) BOD values. Therefore, once a COD/BOD factor is determined, more accurate BOD values and organic loadings can be obtained from COD measurements than from BOD measurements when toxicity is suspected.

10.04 DISSOLVED OXYGEN

Average dissolved oxygen concentrations (Table 19) in the ponds during the study period were good. Except for gross overloading during January and February causing anaerobic conditions, especially in the settling pond and the first polishing pond, oxygen levels were within the range of 0.6-2.6 mg/l recommended by Mueller⁸ for maximum oxygen uptake by bacterial floc. A paper by Eckenfelder⁷ described filamentous growths as obligatory aerobes which flourish in the presence of a readily available carbon source and at oxygen levels below 0.5 mg/l, oxygen uptakes are low. Since the filamentous growths have a high surface area to volume ratio, they will consume most of the available oxygen. High oxygen concentrations tend to favor floc-forming bacteria.

Based on the results of this study and the data discussed in the above papers, it is feasible that additional aeration in the settling basin would afford an increase in BOD removals; however, an increase of not more than 5 percent would be anticipated.

10.05 NUTRIENT REMOVAL

Nitrogen and phosphorous removals during the study period averaged 36 percent and 37 percent, respectively. The settling pond afforded nitrogen removals of 14.8 percent and phosphorous removals of 10.3 percent. Primary nutrient reductions occurred through the polishing ponds. Nitrogen concentrations exhibited reductions of 21.2 percent and phosphate concentrations decreased an average of 25.7 percent. Nutrient removals were based on dosed influent concentrations.

Ecological studies at Auburndale indicated that the treatment process was well balanced nutritionally and that the microbiota present were favorable for bio-oxidation of the citrus wastewater. Under aerobic conditions, ammonia nitrogen and organic nitrogen concentrations would be expected to decrease while nitrate nitrogen concentrations would be expected to increase. Data presented in Table 19 show that although ammonia nitrogen concentrations decreased, organic nitrogen increased and nitrate nitrogen remained virtually unchanged. Settling pond effluent samples indicate a substantial increase (approximately 65 percent) in organic nitrogen over the influent samples. Appreciable quantities of organic matter (BOD) in the settling pond wastewater probably contributed to further production of plant biomass. The biomass contains significant quantities of proteinaceous material which, in turn, contributed to the higher organic nitrogen concentrations experienced in the settling pond effluent. Organic nitrogen removals of the order of 20 percent were indicated between the settling pond and the final polishing pond effluent.

Nitrate nitrogen concentrations probably remained low due to the depth of the settling pond and the long detention time of the treated wastewater in the pond. Since no additional aeration was provided in this pond, the only oxygenation was due to surface aeration. Therefore, the settling pond served as a facultative device where aerobic conditions prevailed at or near the surface and anaerobic conditions, favoring denitrification, prevailed in the deeper areas of the pond.

Nitrogen and phosphorous analyses were made on unfiltered samples throughout this study since this was representative of the actual conditions from pond to pond and in the treatment plant effluent. Further studies should include duplicate analyses on filtered and unfiltered samples in order to substantiate the above findings.

10.06 REUSE OF TREATMENT PLANT EFFLUENTS IN CITRUS PROCESSING PLANT

Chemical analyses indicate substantial quantities of nitrogen (3.63 mg/l) and phosphorus (0.74 mg/l) in the effluent stream. BOD concentrations average about 30 mg/l and suspended solids concentrations average 27 mg/l.

Citrus processing water requirements generally fall into three categories: (1) process; (2) cooling; and (3) steam generation. Process water should be of potable quality since it comes in contact with the product. Treatment plant effluent would not be suitable for use as process water without further treatment. Additional treatment would also be required for steam generation. Primary water consumption is for cooling water in the shell and tube exchangers. Since the average temperature of the treatment plant effluent approximates that of ground water, it would be applicable for use as cooling water. The quality of the treatment plant effluent is acceptable without further treatment; however, due to the nutrient still remaining in the treated effluent, bacterial slime buildup normally encountered in the tube exchangers would be accelerated. Therefore, additional slime control chemicals would be required.

The major disadvantage of reusing the treatment plant effluent at Auburndale at the present time would be the costs involved to pump the water back to the process plant.

10.07 Cost of Treatment

The waste load entering the Auburndale waste treatment plant for the 1969-70 season was generated from the processing of approximately 16×10^6 boxes of fruit. The treatment plant treated a total of 3,010,000# BOD. It should be pointed out that this plant still does not function properly and that part of the waste loading has frequently been bypassed around the treatment plant. This is, of course, reflected in a high cost of treatment based on #BOD.

Total Construction Cost	\$616,000
Depreciation	145,000
(Based on 5 yr. @ 6%)	
Direct Expense	134,000
Annual Treatment Cost	279,000
#BOD Treated	3.01×10^6 #
Boxes Fruit Processed	16×10^6

Cost of Treatment

\$/#BOD	\$0.090
\$/Box Fruit	\$0.017

SECTION 11

AERATED LAGOON DESIGN

11.01 GENERAL

An aerated lagoon is a pond for the treatment of sewage or industrial wastes which is oxygenated by means of induced surface aeration and by mechanical or diffused aeration units. The depth of an aerated lagoon varies from 6 to 12 feet. Other factors affecting treatment in an aerated lagoon system are sunlight, wastewater and ambient temperatures, nutrient levels, algae, evaporation, percolation, and sedimentation. Mixed liquor suspended solids in an aerated lagoon system are generally low (100 - 300 mg/l) and BOD removal is a function of the initial organic load, detention time, and temperature. Oxygen levels of at least 2.0 mg/l should be maintained throughout the basin in order to insure effective biological treatment and to reduce the possibility of odors. Mechanical or diffused aeration units should be so arranged as to maintain an oxygen level of at least 1.5 mg/l DO throughout the system. Eckenfelder³ suggests spacings of 200 feet at power levels of 0.015 - 0.02 horsepower per 1,000 gallons of basin volume to supply the required oxygen levels; however, these levels are inadequate to maintain solids in suspension. Both the kinetic studies and the ecological studies at Auburndale indicate a BOD:N:P ratio of 150:5:1 affords excellent nutrient levels for an effective biological process.

11.02 EXPERIMENTAL DATA

Based on daily operating data, supported by survey data of the 1966-67 citrus processing season and recent studies at Auburndale, combined wastewaters from The Coca-Cola Company and Adams at present (in full operation) have the following characteristics:

Flow, mgd	30
BOD (average) mg/l	130
BOD (average), lbs/day	32,500
BOD removal rate coefficient ($k_{20^{\circ}\text{C.}}$)	1.46
Temperature coefficient (θ)	1.05
Wastewater temperature, $^{\circ}\text{F.}$	91.5
Minimum monthly ambient temperature, $^{\circ}\text{F.}$	59.0

Monthly average data summarized in Table 20 indicate that the present system operating as an aerated lagoon system will afford average BOD removals of approximately 72 percent. This is significantly lower than the 90 percent organic removal required by the Florida Air and Water Pollution Control Commission.

Controlled flow rates during May and June, 1969, of 5 mgd and 10 mgd, respectively, indicate that the present facility is capable of BOD removals of the order of 90 percent at flow rates of not more than 6.4 mgd.

11.03 DESIGN CRITERIA

Based on supporting data collected during the 1968-69 processing season, laboratory studies at Auburndale and theoretical considerations outlined by Eckenfelder,³ the following design criteria are suggested for 90% BOD removal:

	Actual Operation (5 mgd & 10 mgd Studies)	Theoretical (Eckenfelder ³)
Average flow, mgd	30	30
Influent BOD, mg/l	130	130
Effluent BOD, mg/l	12	12
GIVEN		
Loading:		
BOD, lbs/day	32,500	32,500
BOD, lbs/acre (including polishing ponds)	550	677
CALCULATED		
Aeration:		
Area, acres	51	40
Pond depth, feet	12	12
Oxygen required, lbs/hr	1,584	1,584
Surface, lbs/hr	562	440
Mechanical, lbs/hr	1,022	1,144
Total horsepower ¹	410	460
Polishing ponds:		
Area, acres	8-15	8-15
Pond depth, feet	5.0	5.0
Nutrient requirement:		
Nitrogen, lbs/day	1,210	1,210
Phosphorus, lbs/day	177	177
Average $k_{20}^{\circ}\text{C}$.	1.46	1.46
Wastewater temperature, $^{\circ}\text{F}$.	91.5	91.5
Temperature coefficient, θ	1.05	1.05
Average ambient temperature (winter), $^{\circ}\text{F}$.	59.0	59.0

¹Since six aerators of 75 horsepower each are in the existing aeration pond, additional aerators totalling 450 horsepower would be required in order to be spaced properly for proper aeration and mixing in the larger expanded facilities.

A summary of supporting data is presented in Tables 20 and 15 and sample calculations are given in Appendix 5.

SECTION 12

SUGGESTED DESIGN PARAMETER EXTENDED AERATION

12.01 GENERAL

The following design parameters are based as much on the engineer's estimates derived from experience during the course of this research as on actual data obtained during the investigation.

12.02 PRELIMINARY BACKGROUND DATA

Laboratory and small scale pilot plant studies should be made prior to design. Process variables, waste characteristics, and basic operating parameters should be studied. BOD removal rates and variations, oxygen requirements, nutrient levels, excess sludge production and settling rates should also be determined.

12.03 DESIGN PARAMETERS

Citrus processing wastewaters are extremely variable regarding both hydraulic and organic loadings. Therefore, average maximum flow and loading rates rather than overall average rates should be used for design purposes in order to continuously meet minimum organic removal criteria.

Basic design parameters are as follows:

Aeration

Depth, feet	10-12
Loading, pounds BOD/1,000 cu ft	20
Mechanical aeration, hp/330 lbs BOD applied	10
MLSS, pounds/pound BOD applied	10-12
MLSS, mg/l	2,000-6,000
Dissolved oxygen, mg/l	1.5-2.5
Sludge recirculation, percent, variable	0-100
Clarifier overflow, gal/day/ft ²	500
Waste sludge, lbs/lbs BOD applied	0.3-0.4
Sludge digestion	Aerobic
Nutrient, BOD:N:P	150:5:1

Relationships between sludge recirculation and sludge settleability, dissolved oxygen levels, and degree of treatment, along with sludge buildup and sludge wasting, require further investigation.

TABLE 1
WASTEWATER POND CHARACTERISTICS
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

	Aeration Pond (No. 1)	Settling Pond (No. 2)		Polishing Ponds		Total System
		Sludge Section	Remainder	Total	(No. 3) (No. 4)	
Water depth, feet	11.7	14.2	9.7		5.0	4.5
Bottom dimensions, feet:						
Length	380	210	327	537	576	464
Width	235	439	439	439	463	581
Area, acres:						
Bottom	2.05	2.11	3.29	5.40	6.12	6.19
Water surface	3.15	2.72	4.06	6.78	6.85	6.85
Capacity, mg:						
Over bottom	7.815	8.305	10.404	18.709	9.963	9.074
Over slopes	1.889	0.906	1.153	2.059	0.583	0.475
Total	9.704	9.211	11.557	20.768	10.546	9.549
Capacity (min.), mg	8.07					
Cross section, area, s.f. (1)		4,536				

(1) Over hopper bottom

TABLE 2

WASTEWATER FLOW DATA
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA

Federal Water Quality Administration
 Grant No. WPRD 38-01-67

Date	Day of Week	Weir No. 1 (1)			Weir No. 2 (2)			Area Precipitation Inches (3)
		M G D			M G D			
		Peak	Min.	Avg.	Peak	Min.	Avg.	
1966								
Nov. 4	Fri				21.5	1.6	9.5	
Nov. 5	Sat				19.7	4.4	9.5	
Nov. 6	Sun				12.9	4.2	8.1	
Nov. 7	Mon				26.2	4.2	11.2	
Nov. 8	Tues				17.9	3.2	9.5	
Nov. 9	Wed	12.1	2.0	6.6	23.4	0.5	9.5	
Nov. 10	Thurs	17.1	2.8	8.5	18.9	1.9	9.5	
Nov. 11	Fri	18.5	3.0	7.9	17.9	1.6	9.5	
Nov. 12	Sat	11.4	2.1	5.5	21.9	0.3	6.7	
Nov. 13	Sun	5.0	0.9	2.8	8.1	0.3	3.2	
Nov. 14	Mon	9.6	0.2	3.4	14.4	0.3	4.9	
Nov. 15	Tues	9.6	0.1	4.3	15.8		6.1	
Nov. 16	Wed	10.6	0.6	5.2	14.8		6.7	
Nov. 17	Thurs	10.6	0.3	4.4	14.4		5.4	
Nov. 18	Fri	11.4	0.3	4.4	25.0		7.5	
Nov. 19	Sat	8.5	1.4	4.4	14.4	1.4	6.7	
Nov. 20	Sun	7.0	0.3	2.4	9.5	0.3	3.2	
Nov. 21	Mon	16.7	0.6	5.5	17.9	0.8	8.3	
Nov. 22	Tues	9.6	0.6	4.2	16.1	0.4	8.1	
Nov. 23	Wed	9.6	0.6	4.8	19.7	0.8	8.9	
Nov. 24	Thurs	1.6		0.9	5.4		1.1	
Nov. 25	Fri	10.6		4.2				
Nov. 26	Sat	15.8	0.7	6.4	12.8		3.8	
Nov. 27	Sun	3.2	0.1	2.0	6.7		1.9	
Nov. 28	Mon	8.5	0.0	3.6	10.2		3.2	0.05/0.08
Nov. 29	Tues	7.9	0.4	4.1	14.8		4.2	
Nov. 30	Wed	7.6	0.4	4.4	14.4	0.3	4.7	
Dec. 1	Thurs	7.6	0.0	3.4	13.4		4.9	
Dec. 2	Fri	6.4	0.0	2.9	14.4		4.9	
Dec. 3	Sat	4.2	0.1	1.8	11.2		3.8	
Dec. 4	Sun	0.8		0.8	3.4		0.5	/0.08
Dec. 5	Mon	4.7		4.1	14.4		4.9	0.13/0.02
Dec. 6	Tues	10.6	0.3	5.7	19.7	1.4	6.7	
Dec. 7	Wed	19.6	0.2	9.8	23.4	4.4	11.2	

TABLE 2
(continued)

WASTEWATER FLOW DATA
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Date	Day of Week	Weir No. 1 (1)			Weir No. 2 (2)			Area Precipitation Inches (3)
		MGD			MGD			
		Peak	Min.	Avg.	Peak	Min.	Avg.	
1966								
Dec. 8	Thurs	15.8	6.4	10.6	17.9	4.7	11.8	
Dec. 9	Fri	16.7	5.8	11.0	25.4	5.4	13.4	
Dec. 10	Sat	12.9	7.0	10.1	19.7	8.1	13.1	
Dec. 11	Sun	7.0	0.2	2.4	6.1	2.6	4.9	0.02/
Dec. 12	Mon	4.4	0.3	1.9	17.2	3.0	8.9	0.63/0.85
Dec. 13	Tues	8.2	1.2	5.2	17.9	11.2	14.4	0.30/0.25
Dec. 14	Wed	11.4	4.2	7.6	21.5	9.5	13.4	0.02/
Dec. 15	Thurs	6.4	0.9	3.5	17.9	3.2	12.2	
Dec. 16	Fri	16.2	4.7	8.0	21.5	8.6	15.1	
Dec. 17	Sat	10.6	2.6	5.8	21.5	7.2	15.1	0.02/
Dec. 18	Sun	3.7		1.6	11.2	5.4	8.1	0.04/0.06
Dec. 19	Mon	12.5	0.8	6.3	25.0	6.6	14.8	
Dec. 20	Tues	12.1	9.0	9.1	27.4	16.1	13.4	
Dec. 21	Wed	8.2	0.1	5.5	16.1	4.9	9.9	
Dec. 22	Thurs	9.6	0.0	6.2				
Dec. 23	Fri	12.1	1.8	8.0	21.9	5.4	12.8	
Dec. 24	Sat				6.1	0.8	3.4	0.07/0.08
Dec. 25	Sun				4.2	0.8	2.6	
Dec. 26	Mon				8.0	2.6	4.2	
Dec. 27	Tues				12.8	3.2	6.6	
Dec. 28	Wed	11.4	0.9	5.2	19.7	3.4	12.2	
Dec. 29	Thurs	13.3	11.4	12.1	25.4	14.4	18.6	/T
Dec. 30	Fri	13.3	8.5	11.4	22.7	12.8	17.2	0.02/
Dec. 31	Sat	12.9	4.7	10.2	21.5	12.8	16.5	
1967								
Jan. 1	Sun	4.7	0.1	1.5	6.6	0.8	3.4	
Jan. 2	Mon	22.5	0.3	11.2	27.4	4.2	14.8	
Jan. 3	Tues	21.5	9.9	16.7	27.4	18.9	20.4	
Jan. 4	Wed	10.2	4.7	6.8	23.8	13.1	18.9	0.31/0.46
Jan. 5	Thurs				18.9	6.1	12.5	0.01/
Jan. 6	Fri				24.2	8.6	15.8	
Jan. 7	Sat				21.9	14.1	16.8	
Jan. 8	Sun				14.8	0.5	8.9	/0.01
Jan. 9	Mon				18.2	0.5	8.9	

TABLE 2
(continued)

WASTEWATER FLOW DATA
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY -- AUBURNDALE, FLORIDA

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Date	Day of Week	Weir No. 1 (1)			Weir No. 2 (2)			Area
		M G D			M G D			Precipitation
		Peak	Min.	Avg.	Peak	Min.	Avg.	Inches (3)
1967								
Jan. 10	Tues				24.2	14.1	18.6	
Jan. 11	Wed	8.9	7.3	5.4	27.4	16.8	21.9	0.11/0.28
Jan. 12	Thurs	9.6	7.9	8.3	29.5	18.6	21.9	
Jan. 13	Fri	11.0	6.7	9.2	28.7	17.5	21.5	
Jan. 14	Sat	11.4	7.6	9.7	26.6	17.5	21.5	
Jan. 15	Sun	9.6	1.8	7.1	25.8	11.5	16.1	/0.22
Jan. 16	Mon	10.2	1.6	5.0	27.4	10.8	19.7	0.42/0.12
Jan. 17	Tues	13.3	6.7	9.1	27.4	18.7	20.4	
Jan. 18	Wed	11.0	7.3	9.4	24.6	11.2	17.9	
Jan. 19	Thurs	11.0	5.8	9.1	23.8	14.4	17.9	
Jan. 20	Fri	9.9	7.0	7.7	23.4	15.8	17.9	
Jan. 21	Sat	9.2	6.7	8.2	23.4	15.8	17.9	
Jan. 22	Sun	8.9	2.0	5.6	17.9	9.8	13.4	
Jan. 23	Mon	9.6	1.4	5.0	24.2	9.8	16.1	0.02/
Jan. 24	Tues				25.4	16.1	21.5	
Jan. 25	Wed				30.3	17.5	22.7	0.03/0.02
Jan. 26	Thurs				23.4	0.9	14.4	
Jan. 27	Fri				31.6	19.3	24.2	/0.10
Jan. 28	Sat				26.2	13.4	19.7	0.07/
Jan. 29	Sun				19.7	11.5	15.1	
Jan. 30	Mon				29.9	11.2	19.7	
Jan. 31	Tues	11.4	8.5	10.2	27.4	17.9	22.3	
Feb. 1	Wed	12.1	4.2	9.9	29.9	16.1	23.4	
Feb. 2	Thurs	12.1	5.8	9.3	33.3	19.7	23.4	
Feb. 3	Fri	12.1	8.5	10.6	34.2	22.3	26.2	
Feb. 4	Sat	10.2	8.5	9.6	31.6	20.4	25.4	
Feb. 5	Sun	8.5		3.0	25.0	14.1	19.7	
Feb. 6	Mon	16.2	0.06	8.5	31.2	12.9	21.5	
Feb. 7	Tues	12.9	10.2	12.1	31.6	21.9	24.2	0.21/0.36
Feb. 8	Wed	16.2	10.2	12.1	27.4	22.3	22.3	0.05/0.35
Feb. 9	Thurs	16.7	3.4	8.5	31.6	12.9	23.4	2.35/2.00
Feb. 10	Fri	11.0	2.4	5.4	17.5	8.3	14.1	0.21/
Feb. 11	Sat	11.4	10.2	10.6	31.6	15.1	23.4	

TABLE 2
(continued)

WASTEWATER FLOW DATA
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDAL, FLORIDA

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Date	Day of Week	Weir No. 1 (1)			Weir No. 2 (2)			Area Precipitation Inches (3)
		MGD			MGD			
		Peak	Min.	Avg.	Peak	Min.	Avg.	
1967								
Feb. 12	Sun	9.6	0.1	3.0	24.6	7.2	18.9	0.09/0.18
Feb. 13	Mon	13.7	0.4	8.5	21.9	2.2	14.4	0.69/0.48
Feb. 14	Tues	14.1	12.1	10.2	25.8	11.2	18.9	0.03/
Feb. 15	Wed	13.3	8.5	10.9	32.5	21.5	25.0	
Feb. 16	Thurs	14.1	5.5	10.9	36.0	22.3	27.4	
Feb. 17	Fri	14.1	7.0	12.1	36.9	17.9	27.4	
Feb. 18	Sat	12.9	7.9	10.9	38.2	22.7	27.4	
Feb. 19	Sun	10.2	3.4	8.5	34.2	18.2	25.4	
Feb. 20	Mon	13.3	4.7	8.5	37.8	18.2	27.4	
Feb. 21	Tues	15.4	4.2	10.2				0.02/1.00
Feb. 22	Wed	7.0	3.0	5.0				1.42/0.29
Feb. 23	Thurs	10.2	1.4	4.2				0.06/
Feb. 24	Fri	12.9	10.2	12.1				
Feb. 25	Sat	11.4	8.5	10.2				
Feb. 26	Sun	12.1	3.0	7.0				
Feb. 27	Mon	12.9	2.0	9.3				
Feb. 28	Tues	14.5	7.3	9.3				
Mar. 1	Wed	14.9	8.5	12.1				
Mar. 2	Thurs	14.1	8.5	12.1				
Mar. 3	Fri	14.1	10.2	12.1				
Mar. 4	Sat	10.2	5.5	8.5				
Mar. 5	Sun	11.4	9.9	10.2				
Mar. 6	Mon	10.2	4.7	8.5				
Mar. 7	Tues	19.0	7.3	9.3	27.4	19.7	23.4	/0.55
Mar. 8	Wed	7.6	7.9	6.1	23.4	9.5	17.9	0.32/0.08
Mar. 9	Thurs	13.7	4.2	7.9	28.7	8.6	19.7	
Mar. 10	Fri	12.9	6.7	9.2	27.8	20.0	25.4	0.02/
Mar. 11	Sat	12.1	10.2	11.0	33.8	23.4	27.4	
Mar. 12	Sun	10.2	1.8	5.5	27.4	10.5	19.7	
Mar. 13	Mon	6.4	6.4	3.9	21.5	7.2	14.4	
Mar. 14	Tues	12.1	12.1	9.2	25.4	14.4	18.9	
Mar. 15	Wed	7.0	7.0	6.4	24.2	10.2	16.1	
Mar. 16	Thurs	7.0	7.0	5.5	23.4	10.2	16.1	
Mar. 17	Fri	7.0	7.0	5.5	26.6	10.2	17.9	

TABLE 2
(continued)

WASTEWATER FLOW DATA
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Date	Day of Week	Weir No. 1 ⁽¹⁾			Weir No. 2 ⁽²⁾			Area Precipitation Inches ⁽³⁾
		M G D			M G D			
		Peak	Min.	Avg.	Peak	Min.	Avg.	
1967								
Mar. 18	Sat	11.0	11.0	8.5	26.2	12.2	17.9	/0.17 0.32/0.11 0.23/
Mar. 19	Sun	9.6	9.6	4.2	14.4	6.7	10.2	
Mar. 20	Mon	4.2	4.2	3.0	14.8	4.7	8.6	
Mar. 21	Tues	0.2	0.2	4.4	19.7	12.9	12.9	
Mar. 22	Wed	5.5	5.5	4.2	25.4	14.1	18.6	
Mar. 23	Thurs	14.1	14.1	7.0	29.5	15.8	21.5	
Mar. 24	Fri	12.1	12.1	10.2	12.9	27.4	19.7	
Mar. 25	Sat	4.2	4.2	4.2	21.5	13.4	17.9	
Mar. 26	Sun	3.4	3.4	3.0	15.4	9.5	11.2	
Mar. 27	Mon			3.0	17.9	5.9	12.9	
Mar. 28	Tues	20.0	20.0	8.5	29.5	11.8	19.7	
Mar. 29	Wed	12.1	12.1	7.0	25.4	16.1	20.8	
Mar. 30	Thurs	12.1	12.1	7.6	25.4	16.8	21.5	
Mar. 31	Fri	7.9	7.9	7.0	23.4	16.1	21.2	
Apr. 1	Sat	12.1	4.2	7.3	21.5	13.4	17.9	
Apr. 2	Sun	3.7		3.0	14.4	9.5	11.2	
Apr. 3	Mon	12.1		5.5	17.9	6.7	12.9	
Apr. 4	Tues	14.1	3.7	8.5	22.7	8.1	16.1	
Apr. 5	Wed	19.0	14.1	16.2	24.6	19.3	21.5	
Apr. 6	Thurs	18.5	10.2	14.1	24.2	17.9	21.5	
Apr. 7	Fri	16.7	7.0	12.1	23.8	14.8	19.7	
Apr. 8	Sat	21.0	3.0	11.0	22.3	11.2	16.8	
Apr. 9	Sun	8.5	2.0	4.2	10.5	7.5	8.6	
Apr. 10	Mon	14.1	10.2	7.0	16.1	7.8	11.8	
Apr. 11	Tues	14.1	10.6	12.1	21.9	19.7	21.5	
Apr. 12	Wed	20.0	13.3	14.9	23.4	18.9	21.5	
Apr. 13	Thurs	24.1	13.3	18.5	23.4	17.9	19.7	
Apr. 14	Fri	24.1	11.4	16.2	23.4	17.9	19.7	
Apr. 15	Sat	16.2	13.7	14.9	18.2	13.4	15.1	
Apr. 16	Sun	14.1	5.0	7.0	16.1	8.1	9.5	
Apr. 17	Mon	19.5	3.0	14.1	19.6	6.7	14.4	
Apr. 18	Tues	19.0	10.2	14.9	17.8	11.2	12.9	
Apr. 19	Wed	19.5	15.4	18.5	25.4	13.1	21.5	

TABLE 2
(continued)

WASTEWATER FLOW DATA
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Date	Day of Week	Weir No. 1 (1)			Weir No. 2 (2)			Area Precipitation Inches (3)
		MGD			MGD			
		Peak	Min.	Avg.	Peak	Min.	Avg.	
1967								
Apr. 20	Thurs	18.5	14.5	12.1	25.4	23.4	25.4	
Apr. 21	Fri	12.1	9.2	10.2				
Apr. 22	Sat	8.5	4.2	5.5				
Apr. 23	Sun	4.2	3.0	3.0				
Apr. 24	Mon	10.2	2.6	4.2				
Apr. 25	Tues	12.1	8.5	10.2				
Apr. 26	Wed	10.2	7.9	8.5				
Apr. 27	Thurs	11.0	4.7	10.2				
Apr. 28	Fri	12.1	6.1	10.2				
Apr. 29	Sat	11.4	9.2	10.2				
Apr. 30	Sun	9.2	1.1	3.4				
May 1	Mon	12.1	1.1	5.5				
May 2	Tues	10.2	4.2	7.0				
May 3	Wed	11.4	2.0	5.5				
May 4	Thurs	11.0	4.4	8.5				
May 5	Fri							
May 6	Sat							0.85/0.54
May 7	Sun							
May 8	Mon							0.01/
May 9	Tues							
May 10	Wed	11.0	9.9	10.2	21.5	16.1	17.9	
May 11	Thurs	9.2	3.4	5.5	17.9	11.5	14.4	
May 12	Fri	10.2	2.1	8.5	20.4	11.2	16.1	
May 13	Sat	10.2	3.7	7.0	19.3	11.8	16.1	
May 14	Sun	3.4	1.4	2.0	12.2	3.16	6.7	
May 15	Mon	10.2	1.1	4.2	18.7	3.16	11.2	
May 16	Tues	11.0	10.2	10.2	21.1	1.7	18.7	
May 17	Wed	10.2	2.6		17.9	11.2	14.4	0.10/
May 18	Thurs	12.5	3.0					
May 19	Fri	11.7	10.6					
May 20	Sat	11.4	3.9					
May 21	Sun	26.4	3.0					
May 22	Mon	26.4	3.4					1.29/2.26
May 23	Tues	12.1	4.2					0.11/0.06

TABLE 2
(continued)

WASTEWATER FLOW DATA
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Date	Day of Week	Weir No. 1 (1)			Weir No. 2 (2)			Area Precipitation Inches (3)
		MG D			MG D			
		Peak	Min.	Avg.	Peak	Min.	Avg.	
1967								
May 24	Wed	12.1	4.2		21.5	12.9	16.1	0.10/0.01
May 25	Thurs	14.1	3.0	8.5	15.8	9.5	11.8	
May 26	Fri	14.1	6.1	10.2	18.9	11.5	15.1	
May 27	Sat	12.5	4.2	8.5	18.9	12.2	16.1	
May 28	Sun	4.7	3.7	4.2	11.8	5.4	8.1	
May 29	Mon	5.5	3.4	4.7	11.8	5.6	6.7	
May 30	Tues	14.1	3.0	4.2	18.9	4.0	12.9	
May 31	Wed	12.9	5.5	8.5	16.8	12.5	14.4	
June 1	Thurs	16.2	2.0	10.2	42.9	10.8	17.9	
June 2	Fri	33.8	5.0	16.2	42.9	16.5	21.5	3.95/1.72
June 3	Sat	21.0	4.2	10.2	22.7	15.4	17.9	1.13/0.32
June 4	Sun	7.0	2.4	4.7	17.5	4.7	11.1	1.97/0.52
June 5	Mon	12.1	1.6	5.5	20.4	5.4	12.9	/0.09
June 6	Tues	16.2	4.2	8.5	20.4	12.9	16.8	0.37/
June 7	Wed	16.2	3.0	10.2	21.2	4.7	16.1	1.23/
June 8	Thurs	7.0	21.0	11.0	21.5	13.4	17.9	
June 9	Fri	19.5	11.4	12.1	25.4	15.4	19.7	/0.15
June 10	Sat	12.1	12.1	12.1	22.7	17.2	19.7	0.52/0.04
June 11	Sun	12.1	4.2	5.5	19.7	12.2	16.1	
June 12	Mon	4.2	3.0	5.5	18.6	5.6	12.9	
June 13	Tues	12.1	10.2	11.0	23.4	15.4	18.2	

(1) Below Adams Packing Company.

(2) Below Adams Packing Company, The Coca-Cola Company, and City of Auburndale Sewage Treatment Plant.

(3) Lake Alfred Experiment Station / Winter Haven Stations of U.S. Weather Bureau.

TABLE 3

DAILY AREA PRECIPITATION

1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA (1)

Federal Water Quality Administration
Grant No. WPRD 38-01-67

S t a t i o n			S t a t i o n		
Date	Lake Alfred Exp. Sta.	Winter Haven	Date	Lake Alfred Exp. Sta.	Winter Haven
1966			1967		
Nov. 2		0.05	Feb. 12	0.09	0.18
Nov. 3	0.05		Feb. 13	0.69	0.48
Nov. 28	0.05	0.08	Feb. 14	0.03	
			Feb. 21	0.02	1.00
Dec. 4		0.08	Feb. 22	1.42	0.29
Dec. 5	0.13	0.02	Feb. 23	0.06	
Dec. 11	0.02				0.55
Dec. 12	0.63	0.85	Mar. 7		0.08
Dec. 13	0.30	0.25	Mar. 8	0.32	
Dec. 14	0.02		Mar. 10	0.02	
Dec. 17	0.02		Mar. 28		0.17
Dec. 18	0.04	0.06	Mar. 29	0.32	0.11
Dec. 24	0.07	0.08	Mar. 30	0.23	
Dec. 29		T			
Dec. 30	0.02		May 6	0.85	0.54
1967			May 8	0.01	
Jan. 4	0.31	0.46	May 17	0.10	
Jan. 5	0.01		May 22	1.29	2.26
Jan. 8		0.01	May 23	0.11	0.06
Jan. 11	0.11	0.28	May 24	0.10	0.01
Jan. 15		0.22			
Jan. 16	0.42	0.12	Jun. 2	3.95	1.72
Jan. 23	0.02		Jun. 3	1.13	0.32
Jan. 25	0.03	0.02	Jun. 4	1.97	0.52
Jan. 27		0.10	Jun. 5		0.09
Jan. 28	0.07		Jun. 6	0.37	
			Jun. 7	1.23	
Feb. 7	0.21	0.36	Jun. 9		0.15
Feb. 8	0.05	0.35	Jun. 10	0.52	0.04
Feb. 9	2.35	2.00	Jun. 15		T
Feb. 10	0.21				

(1) From U. S. Weather Bureau Records. Precipitation expressed in inches.

TABLE 4
RAW WASTEWATER ANALYSES AT WEIR NO. 1
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA (1)

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Dates	Days of Week	Flow MGD	S o l i d s		5-day BOD mg/l	Nit. (N) mg/l	Phos. (P) mg/l	Total Alk. mg/l	pH	Temp. °F.	Remarks
			T o t a l mg/l	S u s p e n d e d mg/l	S e t t l . ml/l						
1966 Nov. 29-30 Dec.	Tu-W	4.70	502	69	48	<0.1	118	1.40	1.60	101	7.2
1-2	Th-F	2.90	410	56	40	<0.1	94	1.12	1.30	108	6.9
6-7	Tu-W	6.50	455	89	42	<0.1	108	2.52	1.28	149	7.0
8-9	Th-F	9.61	382	52	42	<0.1	78	0.28	0.40	104	6.9
13-14	Tu-W	7.67	270	63	82	<0.1	75	2.41	1.12	143	7.0
15-16	Th-F	6.06	305	65	72	<0.1	110	3.81	1.28	148	6.9
20-21	Tu-W	7.73	325	59	36	<0.1	120	2.69	0.58	168	7.2
22-23	Th-F	8.89	373	79	23	<0.1	158	2.97	0.80	146	6.7
27-28	Tu-W	3.71	300	67	17	0.5	65	1.2	0.3		90
30-31	F-Sa	11.7	334	31	100	0.4	80	0.9			
1967 Jan.	Tu-W	8.73	315	70	28	0.3	100	1.8	0.3		91
3-4	F-Sa		360	63	24	0.2	98	1.3	0.6	146	93
6-7	Tu-W	8.01	338	84	28	0.2	98	0.8	0.03	101	88
10-11	F-Sa	9.20	280	68	17	0.1	160	1.7	0.8	100	90
13-14											

(2)

TABLE 4
(continued)
RAW WASTEWATER ANALYSES AT WEIR NO. 1
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA (1)

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Dates	Days of Week	Flow MGD	S o l i d s			5-day BOD mg/l	Nit. (N) mg/l	Phos. (P) mg/l	Total Alk. mg/l	pH	Temp. °F.	Remarks
			T o t a l mg/l	S u s p e n d e d mg/l	S e t t l . % Vol.							
1967												
Jan. 19-20	Th-F	7.20	466	51	88	150	0.9	1.0	88	6.9	87	
20-21	F-Sa	7.97	349	36	86	155	1.3	0.5	100	6.8	90	
24-25	Tu-W		352	113	24	210	0.6	0.8	80	7.2	89	(3)
26-27	Th-F		300	22	100	115	0.7	0.7	993	6.9	92	
Jan. 31- Feb. 1	Tu-W	9.90	436	23	78	145	3.2	0.8	151	9.2	91	(4)
Feb. 3-4	F-Sa	9.90	486	30	80	190	1.8	0.7	102	7.4	91	(3)
7-8	Tu-W	12.1	308	21	95	70	0.4	0.4	98	7.3	89	
10-11	F-Sa	10.2	399	30	87	85	1.5	1.1	80	6.9	88	
15-16	W-Th	12.1	300	32	94	155	1.2	0.8	93	7.2	90	
17-18	F-Sa	11.4	552	40	85	84	1.6	1.4	152	7.6	86	
21-22	Tu-W	5.50	404	44	82	280	1.6	0.7	130	7.0		
Feb. 28- Mar. 1	Tu-W	12.1	425	28	100	145	1.1	0.5	98	6.9		
Mar. 3-4	F-Sa	8.90	882	58	97	370	2.4	1.0	95	6.4	91	
7-8	Tu-W	7.90	593	27	96	150	1.8	0.7	125	7.3	90	

TABLE 4
(continued)
RAW WASTEWATER ANALYSES AT WEIR NO. 1
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA (1)

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Dates	Days of Week	Flow MGD	S o l i d s		5-day BOD mg/l	Nit. (N) mg/l	Phos. (P) mg/l	Total Alk. mg/l	pH	Temp. °F.	Remarks		
			T o t a l mg/l	% Vol.								Suspended mg/l	Sett. ml/l
1967													
Jan.													
19-20	Th-F	7.20	466	72	51	88	0.5	150	0.9	1.0	88	6.9	87
20-21	F-Sa	7.97	349	69	36	86	0.1	155	1.3	0.5	100	6.8	90
24-25	Tu-W		352	82	113	24	0.3	210	0.6	0.8	80	7.2	89
26-27	Th-F		300	84	22	100	0.1	115	0.7	0.7	993	6.9	92
Jan. 31- Feb. 1	Tu-W	9.90	436	66	23	78	0.5	145	3.2	0.8	151	9.2	91
Feb.													(3)
3-4	F-Sa	9.90	486	67	30	80	0.5	190	1.8	0.7	102	7.4	91
7-8	Tu-W	12.1	308	97	21	95	0.1	70	0.4	0.4	98	7.3	89
10-11	F-Sa	10.2	399	52	30	87	0.2	85	1.5	1.1	80	6.9	88
15-16	W-Th	12.1	300	77	32	94	0.1	155	1.2	0.8	93	7.2	90
17-18	F-Sa	11.4	552	90	40	85	0.1	84	1.4	1.4	152	7.6	86
21-22	Tu-W	5.50	404	68	44	82	<0.6	280	1.6	0.7	130	7.0	86
Feb. 28- Mar. 1	Tu-W	12.1	425	75	28	100	0.3	145	1.1	0.5	98	6.9	
Mar.													
3-4	F-Sa	8.90	882	80	58	97	1.1	370	2.4	1.0	95	6.4	91
7-8	Tu-W	7.90	593	67	27	96	<0.1	150	1.8	0.7	125	7.3	90

TABLE 4
(continued)
RAW WASTEWATER ANALYSES AT WEIR NO. 1
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA (1)

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Dates	Days of Week	Flow MGD	S o l i d s		Sett. ml/l	5-day BOD mg/l	Nit. (N) mg/l	Phos. (P) mg/l	Total Alk. mg/l	pH	Temp. °F.	Remarks
			T o t a l mg/l	% Vol.								
Average		8.42	400	70		135	1.6	0.8	116	7.1	90	
Maximum		12.1	882	97		370	3.81	1.60	168	9.2	93	
Minimum		2.90	270	31		65	0.4	0.3	80	6.4	87	

(1) 24-hour composite samples initiated and terminated at 4-5 PM unless otherwise indicated.

(2) Nitrate nitrogen - 1.5 mg/l.

(3) Composite composed of three grab samples due to sample pump failure.

(4) Nitrate nitrogen - 0.00 mg/l.

TABLE 5
RAW WASTEWATER ANALYSES AT DARBY AVENUE⁽¹⁾
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Dates	Days of Week	Flow MGD	S o l i d s		5-day BOD mg/l	Nit. (N) mg/l	Phos. (P) mg/l	Total Alk. mg/l	pH	Temp. °F.	Remarks			
			T o t a l mg/l	% Vol.								Suspended mg/l	Sett. ml/l	
1967														
Jan. 31 -														
Feb. 1	Tu-W		330	63	23	96	0.8	120	2.1	0.6	94	7.4	91	(2)
10-11	F-Sa		289	35	24	92	1.0	64	1.0	0.6	85	7.2		(3)

(1) Below Adams Packing Company and The Coca-Cola Company.

(2) 24-hour composite sample initiated and terminated at 5 PM.

(3) 9-hour composite sample. Nitrate nitrogen - 0.1 mg/l.

TABLE 6
RAW WASTEWATER ANALYSES AT WEIR NO. 2
1966-67 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY - AUBURNDALE, FLORIDA⁽¹⁾

Federal Water Quality Administration
Grant No. WPRD 38-01-67

Dates	Days of Week	Flow MGD	S o l i d s				5-day BOD mg/l	Nit. (N) mg/l	Phos. (P) mg/l	Total		Temp. °F.	Remarks
			T o t a l mg/l	% Vol.	Suspended mg/l	% Vol.				Sett. ml/l	Alk. mg/l		
1966													
Nov. 29-30	Tu-W	6.86	1450	84	59	61	<0.1	147	6.44	6.20	130	7.1	
Dec. 1-2	Th-F	6.04	450	49	66	65	<0.1	88	4.20	4.10	132	7.2	
6-7	Tu-W	10.7	388	69	59	66	<0.1	122	3.64	1.48	132	7.1	
8-9	Th-F	13.5	450	56	58	38	<0.1	96	4.20	1.76	118	7.1	
13-14	Tu-W	14.1	272	65	55	31	<0.1	90	4.09	1.64	137	7.0	
15-16	Th-F	15.3	272	62	86	19	<0.1	118	4.09	1.40	146	7.1	
20-21	Tu-W	11.0	344	60	72	89	<0.1	135	5.49	2.00	158	7.3	
22-23	Th-F		268	63	55	62	<0.1	133	2.68	1.42	132	6.8	
27-28	Tu-W	10.4	340	68	20	95	0.5	145	4.20	3.0			
30-31	F-Sa	17.6	340	63	38	100	1.5	110	2.10	1.2			90
1967													
Jan. 3-4	Tu-W	18.4	288	66	40	82	0.6	105	2.0	0.5			90
6-7	F-Sa	16.4	352	74	50	80	2.0	130	2.8	1.0	110	6.8	89
10-11	Tu-W	21.3	319	79	32	100	0.4	80	1.6	0.3	92	6.8	87 (2)
13-14	F-Sa	19.9	323	73	40	100	0.4	120	2.1	0.9	85	6.5	89
19-20	Th-F	17.6	414	62	48	83	0.7	112	1.4	2.3	103	6.9	89
20-21	F-Sa	17.6	336	61	42	83	0.5	128	1.6	2.1	105	7.0	87
24-25	Tu-W	22.7	253	70	26	100	0.2	156	2.7	1.0	101	7.2	89
27	F	25.6	259	85	26	96	0.1	104	1.3	0.8	101	7.1	92 (3)
Jan. 31 - Feb. 1	Tu-W	22.4	289	57	31	94	2.0	100	3.7	1.4	92	7.2	89 (4)
Feb. 3-4	F-Sa	25.0	343	68	26	88	1.0	104	1.4	1.3	101	7.2	89
7-8	Tu-W	21.3	259	61	18	89	0.1	64	0.3	0.7	99	7.3	86
10-11	F-Sa	19.9	389	67	32	94	1.0	80	1.5	1.3	101	7.1	88 (5)
15-16	W-Th	26.4	305	75	36	94	0.3	136	1.8	0.6	93	7.1	88
17-18	F-Sa	26.4	434	95	31	90	0.5	117	2.4	2.8	124	7.0	90
21-22	Tu-W		418	65	48	83	0.6	180	2.3	2.3	111	7.0	86
Feb. 25 - Mar. 1	Tu-W	21.0	453	75	42	86	0.4	152	1.9	1.0	85	6.6	
Mar. 3-4	F-Sa		504	82	34	88	0.4	<31?	3.1	2.0	78	6.0	92
7-8	Tu-W	19.3	513	81	40	90	0.5	260	2.8	1.4	99	6.7	90
Average		17.9	394	69	43	80	<0.5	123	2.8	1.7	111	7.0	89
Maximum		26.4	1450	85	86	100	2.0	<312	6.44	6.20	158	7.3	92
Minimum		6.04	253	49	18	19	<0.1	64	0.3	0.3	78	6.0	86

(1) 24-hour composite samples initiated and terminated at 4 to 5 PM unless otherwise noted.

(2) Nitrate nitrogen - 0.00 mg/l.

(3) 9-hour composite, 7 AM - 4 PM.

(4) Nitrate nitrogen - 0.00 mg/l.

(5) Nitrate nitrogen - 0.03 mg/l.

TABLE 7

**WASTEWATER POND CHARACTERISTICS & EQUIPMENT
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA**

Parameter	Aeration	Settling Pond (No. 2)			Polishing	Ponds	Total System
	Pond (No. 1)	Sludge Section	Remainder	Total	(No. 3)	(No. 4)	
Water depth, feet	11.7	14.2	9.7		5.0	4.5	
Bottom dimensions, feet:							
Length	380	210	327	537	576	464	
Width	235	439	439	439	463	581	
Area, acres:							
Bottom	2.05	2.11	3.29	5.40	6.12	6.19	19.76
Water surface	3.15	2.72	4.06	6.78	6.85	6.85	23.63
Capacity, MMG:							
Over bottom	7.815	8.305	10.404	18.709	9.963	9.074	45.561
Over slopes	1.889	0.906	1.153	2.059	0.583	0.475	5.006
Total	9.704	9.211	11.557	20.768	10.546	9.549	50.567
Cross section, area, sq. ft. (1)		4,536					
Aerators:							
Number		6					
Type		Mechanical					
Horsepower, (each)		75					

(1) Over hopper bottom

TABLE 8
TREATMENT PLANT CHARACTERISTICS
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

	P u m p C o m b i n a t i o n				
	Small	Large	Large Small	Large Large	Large Large Small
Pumping capacity (Name plate), mgd	9.33	16.74	26.07	33.48	42.81
Recirculation (about 100%), mgd	4.5	8.0	12.0	14.5	15.5
Plant influent, mgd:					
Peak	4.8	8.7	14.1	19.0	27.3
Daily:					
Average	4.5	8.1	12.0	14.5	15.6
Maximum	4.8	8.7	14.1	19.0	27.3
Minimum	<2.0	<2.0	<2.0	<2.0	<2.0
BOD load, lbs/day ⁽¹⁾	4,600	8,300	12,300	14,900	16,000
Aeration Pond (No. 1)					
Detention, hours:					
Average	51.7	28.7	19.4	16.0	14.9
Maximum	>116	>116	>116	>116	>116
Minimum	48.5	26.7	16.5	12.2	8.5
BOD load, lb/day/hp	10.2	18.5	27.3	33.1	34.7
Settling Pond (No. 2):					
Sludge removal section:					
Detention, hours:					
Average	49.2	27.3	18.4	15.2	14.2
Maximum	>110	>110	>110	>110	>110
Minimum	46.1	25.4	15.7	11.6	8.1
Horizontal Velocity, fpm:					
Average	0.092	0.17	1.25	0.30	0.32
Maximum	0.098	0.18	0.29	0.39	0.56
Surface Overflow Rate, gpd/s.f.					
Average	38	68	101	122	131
Maximum	40	73	119	160	230

TABLE 8
(continued)

TREATMENT PLANT CHARACTERISTICS
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

	P u m p C o m b i n a t i o n				
	Small	Large	Large Small	Large Large	Large Small
Baffle Overflow Rate, gpd/s.f.:					
Average	10,200	18,500	27,400	33,000	35,600
Maximum	10,900	19,800	32,200	43,300	62,200
Total Basin:					
Detention, hours:					
Average	111	61.6	41.6	34.4	32.0
Maximum	>250	>250	>250	>250	>250
Minimum	104	57.4	35.4	26.3	18.3
Polishing Pond (No. 3):					
Detention, hours:					
Average	56.3	31.3	21.1	17.5	16.2
Maximum	>127	>127	>127	>127	>127
Minimum	52.8	29.1	18.0	13.3	9.3
Polishing Pond (No. 4):					
Detention, hours:					
Average	51.0	28.3	19.1	15.8	14.7
Maximum	>115	>115	>115	>115	>115
Minimum	47.7	26.4	16.2	12.1	8.4
Total Pond System:					
Detention, days:					
Average	11.25	6.25	4.22	3.49	3.24
Maximum	>25.3	>25.3	>25.3	>25.3	>25.3
Minimum	10.52	5.82	3.59	2.66	1.85
BOD load, lbs/day/acre	195	350	522	632	678

(1) Basis average BOD of 123 mg/l.

TABLE 9
AVERAGE ANALYSES 2.4-DAY DETENTION
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

Parameter	Hyacinth	Pond ⁽¹⁾	Percent Reduction
	Influent	Effluent	
Temperature, degrees C.		26.3	
pH	7.3	7.2	1.4
Dissolved oxygen, mg/l	1.9	1.0	47.4
Chemical oxygen demand, mg/l	68.3	47.9	29.9
Biological oxygen demand, mg/l	22.1	12.1	45.2
Total suspended solids, mg/l	33.8	22.5	33.4
Total organic nitrogen, mg/l - N	4.46	3.31	25.8
Ammonia nitrogen, mg/l - N	0.48	0.52	
Nitrite nitrogen, mg/l - N	0.002	0.002	0
Nitrate nitrogen, mg/l - N	0.33	0.34	
Total phosphate, mg/l - P	0.75	0.64	14.7
Total nitrogen, mg/l - N	5.27	4.17	20.9

(1) Average analysis of nine sampling days.

TABLE 10
HYACINTH POND MICROBIOTA
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

ORGANISMS	HYACINTH PLANT ROOTS	HYACINTH POND INFLUENT	HYACINTH POND EFFLUENT
BACTERIA			
FREE FLOATING	•	•	•
CHAIN	•	•	
SPHAEROTILUS NATANS	•	•	
SARCINA	•		•
SPIRILLI		•	
DEGIATOA ALBA			
THIORHODACEAE	•		•
BLUE GREEN ALGAE			
OSCILLATORIA SP.	•	45 (1)	8
GREEN ALGAE			
ANKISTRODESMUS FALCATUS	•	12800	1800
ANKISTRODESMUS TUMIDUS	•	9600	1800
CHLORELLA SP.	•	40	4
DICTYOSPHAERIUM EHERN.	•	80	40
SCENEDESMUS SP.	•		
EUGLENOPHYCEAE			
EUGLENA PISCIFORMIS	•	4	
EUGLENA SP.	•	700	12
PETALOMONAS CARINATA	•		
PETALOMONAS PLAYFAIRI	•		
PERANEMA TRICOPHORUM	•	3	4
TRACHELONONAS VOLVOGINA			
DIATOMS			
CYCLOTELLA COMTA	• (DEAD)		
NAVICULA SP.	• (DEAD)	20	
RHIZOPODA			
AMOEBA VESPERTILIO	•		
PELOMYXA SP.	•		
ZOOFLAGELLATA			
HEXAMITUS INFLATUS	•	160	
MASTIGAMOCHA SP.	•	80	
MONAS SP.	•	320	
DILOMONAS TERMO	•	1800	24
TETRAMITUS PYRIFORMIS	•	640	4
ZOOFLAGELLATA			
CILIATA			
CYCLIDIUM SALTANS	•	4	
CYRTOLOPHOSIS	•		0.25
HALTERIA GRANLINELLA	•		1
LEMBUS FUSIFORMIS	•		
METOPUS SP.	•		
OXYTRICHA PELIONELLA	•		
PARAMECIUM CAUDATA	2	1	
SPIROSTOMUM AMBIGUUM	•		0.25
TRIMYEMA SP.	•		
UROCENTRUM TURBO	•	3	0.5
VORTICELLA SP.	•		
CILIATA			
ROTIFER		1	

(1) NUMBERS, WHERE REPORTED ARE AS ORGANISMS / ml.

TABLE 11
AVERAGE ANALYSIS 5-DAY DETENTION
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

Parameter	Hyacinth Pond ⁽¹⁾		Percent Reduction
	Influent	Effluent	
Temperature, degrees C.		30.3	
pH	6.90	6.86	
Dissolved oxygen, mg/l	1.24	1.00	19.4
Chemical oxygen demand, mg/l	106	56	47.2
Biological oxygen demand, mg/l	56	17	69.6
Total suspended solids	21	4	80.9
Total organic nitrogen, mg/l - N	3.27	1.31	59.9
Ammonia nitrogen, mg/l - N	0.26	1.07	411 ⁽²⁾
Nitrite nitrogen, mg/l - N	0.002	0.001	50.0
Nitrate nitrogen, mg/l - N	0.04	0.03	25.0
Total phosphate, mg/l - P	0.76	0.49	35.5
Total nitrogen, mg/l - N	3.58	2.80	21.8

(1) Average analyses of 5 sampling days. Continuous flow, 5-day detention.

(2) Increase.

TABLE 12
PRESSED LIQUOR ANALYSES (1)
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

Constituent	April 30	May 15	May 26	May 28	June 5	Average
Total Organic Nitrogen, mg/l-N	42	264	239	484	532	312
Ammonia Nitrogen, mg/l-N	2.3	10.6	7.6	5.9	76	20.5
Nitrite Nitrogen, mg/l-N	0.01	0.004	0	0.001	0.21	0.045
Nitrate Nitrogen, mg/l-N	2.0				9.0	5.5
Total Nitrogen, mg/l-N	46.3	274.6	246.6	489.9	617.2	334.9
Total Phosphate, mg/l-N	22.8	53.0	42.0	110.0	85.0	62.6

(1) Liquid squeezed from hyacinth plants.

TABLE 13

AUBURDALE BIOTA
THE COCA-COLA COMPANY
FOODS DIVISION

[illegible]

	4	80	48	40	18	
SCENEDESMUS SP.	•					•
SCHIZOMERIS SP.	•					
STIGEOCLONIUM SP.						•
DICTYOSPHAERIUM EHREN.	48	40	240	3840	1260	•
POLYEDIRIOPSES SPINULOSA	•		•			•
RHIZOCLONIUM SP.	•		•			
ULOTHRIX ZONATA						
VOLVOCALES						
CHLANYDOMONAS SP.			•	•	•	•
SPONDYLODORUM SP.				4	•	•
CHLOROGONIUM SP.			5		1	•
LEPOCINCLIS FLORIDENSIS						•
LEPOCINCLIS MARSSONI			•	•		•
LEPOCINCLIS TEXTA						
EUGLENOPHYCEAE						
CRYPTOGLENA PIGRA			•	24	3	
EUGLENA AGRIS			•			
EUGLENA CLARA			10	20	4	•
EUGLENA DESIS			1	•		
EUGLENA GRACILIS			•	•		
EUGLENA MUTABILIS						•
EUGLENA OXYURIS		4	•	7		•
EUGLENA PISCIFORMIS			•			•
EUGLENA SPIROGYRA			•			•
EUGLENA VIRIDIS	2				24	•
EUGLENA SP.	•	700	13	32		
PERANENA TRICOPHORUM			1	1		
PHACUS LONGICAUDA						
PHACUS PYNAM	1	3	4	•	18	•
TRACHELOMONAS VOLVOCLIMA						
CRYPTOPHYCEAE						
CRYPTOMONAS EROSA			•			•
CYATHOMONAS TRUNCATA						
DINDELABELLATA						
HENIDINIUM NASUTA						•
GYMNOINIUM SP.						•
DIATOMS						
CYCLOTELLA CONTA		20	•	4		
NAVICULA SP.	•			•		•
PINNULARICA SP.						
SURIPELLA SP.				•		•
SYNEDRA JULNA						
NELOSIRA VARIANS						

TABLE 14
AVERAGE WEEKLY OPERATING DATA
1968-69 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY FOODS DIV.
AUBURNDALE, FLORIDA

MONTH	WEEK ENDING	FLOW - MGD			SLUDGE RETURN PERCENT	5-DAY BOD, mg/l			BOD LOADING, lbs/day		COD, mg/l			COD LOADING, lbs/day		COD/BOD RATIO		BOD REM %
		TOTAL	PLANT INFLUENT	RETURN SLUDGE		PLANT INFLUENT	POND 2 EFFLUENT	POND 4 EFFLUENT	PLANT INFLUENT	PLANT EFFLUENT	PLANT INFLUENT	POND 2 EFFLUENT	POND 4 EFFLUENT	PLANT INFLUENT	PLANT EFFLUENT	PLANT INFLUENT	PLANT EFFLUENT	
1968																		
DEC	12/7	21.2	18.8	18.3	94	114	59	18	12878	1878	148	78	20	14338	3433	1.61	2.52	85.1
DEC	12/14	23.7	12.8	11.1	98	107	57	28	8488	2188	171	138	88	18488	8887	1.81	3.88	78.5
DEC	12/21	25.1	17.8	13.2	111	111	47	53	11588	5887	178	124	118	18888	18824	1.84	2.81	48.4
DEC	12/28	25.8	14.8	11.1	74	118	48	45	13715	5375	178	136	128	23287	19354	1.81	1.22	58.1
DEC	1/4	31.8	18.8	12.8	61	103	51	41	18758	5888	287	181	128	52518	18285	2.27	2.97	85.1
1969																		
JAN	1/11	23.8	12.5	11.4	91	151	135	116	18833	17887	213	187	183	24723	18878	1.58	1.93	8
JAN	1/18	21.3	8.1	12.2	134	288	78	48	28247	5858	275	143	94	28858	8881	1.48	2.25	78.8
JAN	1/25	21.8	13.1	8.7	88	178	48	37	18814	3755	178	123	82	21545	3778	1.33	2.74	88.4
JAN	2/1	28.4	18.8	8.8	51	84	-	41	15837	7877	187	138	128	25432	18852	1.88	2.88	58
FEB	2/8	23.8	17.8	5.7	52	98	44	48	14131	8311	145	117	82	21482	12824	1.48	2.38	55.1
FEB	2/15	23.5	21.4	2.1	18	128	48	38	18865	5534	232	134	181	32288	18487	1.84	1.43	72
FEB	2/22	28.5	17.3	3.2	18	151	87	48	18748	5888	221	138	114	28824	18284	1.88	2.85	88.1
FEB	3/1	18.4	13.7	5.7	41	188	48	38	12183	3248	188	184	88	22258	8887	1.88	3.88	73.1
MAR	3/8	13.1	18.7	2.4	22	88	38	27	7881	2485	152	88	85	13118	7818	1.88	3.18	88.1
MAR	3/15	11.8	8.3	2.5	28	43	17	12	3432	817	88	84	52	8821	4828	2.38	4.45	73.1
MAR	3/22	14.2	11.3	2.8	28	82	28	14	5853	1224	134	87	58	12285	5457	2.48	4.51	78.1
MAR	3/29	14.1	18.8	3.5	37	74	31	15	8522	1428	141	87	88	12588	8221	1.88	4.48	78.1
MAR	4/5	13.7	8.7	4.8	41	78	28	14	5584	1187	128	78	54	18447	4372	1.88	3.72	78.1
APR. NO DATA																		
MAY																		
MAY	5/10	11.3	5.5	4.8	88	128	-	8	5835	278	248	88	48	11812	2287	1.88	8.58	85.1
MAY	5/17	11.4	5.8	4.8	87	188	-	8	7454	423	214	88	48	8883	2282	1.38	5.48	84.1
MAY	5/24	15.8	7.2	8.7	121	87	-	8	5228	422	148	73	47	8487	2818	1.88	3.88	84.1
MAY	5/31	18.7	8.3	18.4	125	133	-	18	8221	1377	188	188	58	12888	4851	1.48	3.18	85.1
JUN																		
JUN	6/7	28.8	18.2	18.4	182	158	88	28	13238	2388	281	133	88	22225	7828	1.78	3.28	82.1
JUN	6/14	23.2	13.7	18.8	78	281	51	34	22888	3888	287	188	182	31813	11228	1.48	3.88	83.1
JUN	6/21	25.5	28.5	5.8	24	122	83	47	28885	8884	185	158	112	31588	18214	1.58	2.48	81.1
JUN	6/28	25.4	18.8	8.8	53	77	-	23	18888	3158	145	87	74	28841	18282	1.88	3.28	78.1
AVERAGE (5)																		
MAXIMUM																		
MINIMUM																		

- (1) BASED ON WEIGHTED DAILY DATA
- (2) CHANGEMER TO VALENCIAS
- (3) CONTROL INFLUENT FLOW - 8 mgd MAY 1-18
- (4) CONTROL INFLUENT FLOW - 18 mgd MAY 28 - JUNE 13
- (5) FLOW DATA AND ORGANIC LOADINGS NOT ABSOLUTE DUE TO INTENTIONAL BYPASSING FOR RESEARCH
- (6) BOD & P VALUES CALCULATED FROM CONDITIONS ON DAY W_{H_2} & PO_4 ANALYSES MADE

WEEKLY OPERATING DATA (7)
8-69 CITRUS PROCESSING SEASON
DCA-COLA COMPANY FOODS DIVISION
AUBURNOLE, FLORIDA

T-24

DESIGN CHARACTERISTICS

AERATED LAGOON SYSTEM

THE COCA-COLA COMPANY FOODS DIVISION

AUBURNDALE, FLORIDA

Flow mgd	BOD lbs/day	A e r a t i o n P o n d s		Polishing Ponds Area, acres	Depth, ft	BOD % rem.	BOD Loading lbs/day/acre
		Area, acres	Depth, ft.	Horsepower	DO, mg/l		
11.8(1)	11,550	9.93	11.5	450	4.2	72.3	489
9.5(2)	11,800	9.93	11.5	450	4.9	83.8	500
6.4(3)	6,780	9.93	11.5	450	5.7	91.3	287
5.3(4)	5,930	9.93	11.5	450	6.0	94.5	250
30.0(5)	32,500	51.0	12.0	900	2.0	90.0 ⁺	550

(1) Average data 1968-69 processing season

(2) Average-controlled influent flow June 1969

(3) Average-month of May 1969

(4) Average-controlled influent flow May 1969

(5) Required based on 1968-69 processing season

TABLE 16
SUMMARY OF OPERATIONS 5 MGD FLOW RATE
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

Total influent flow, MG	100.7
Average daily influent flow, MG	5.3
Average daily sludge recirculated, MG	4.8
Average percent sludge recirculated	91.4
Total pounds BOD - influent	112,632
Total pounds BOD - effluent	6,156
Average daily BOD - influent - mg/l	134
Average daily BOD - effluent - mg/l	7
Average BOD removal - percent	94.5
Total pounds COD - influent	174,610
Total pounds COD - effluent	40,413
Average daily COD - influent - mg/l	208
Average daily COD - effluent - mg/l	48
Average COD removal - percent	76.9
COD/BOD influent - average	1.6
COD/BOD effluent - average	6.6
Total pounds suspended solids - influent	15,117
Total pounds suspended solids - effluent	7,559
Average suspended solids - influent - mg/l	18
Average suspended solids - effluent - mg/l	9
Average total pounds MLSS (aeration basin)	3,964
Average MLSS, mg/l	49
Average pounds BOD/pound MLSS	1.5:1
Total hours aeration	2,520
Total pounds oxygen (3.5 lbs O ₂ /HP theoretical)	661,500
Pounds of oxygen / pounds of BOD applied	5.87
BOD load - pounds/day/HP (ave)	14.3
COD load - pounds/day/HP (ave)	22.2
Pounds of oxygen / pound of COD applied	3.79

TABLE 16
(continued)

SUMMARY OF OPERATIONS 5 MGD FLOW RATE
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

Detention time - hours (average)	43.9
Aeration (9.7 MMG)	94.2
Settling (20.8 MMG)	41.7
Sludge removal section (9.2 MMG)	47.5
Polishing pond No. 1 (10.5 MMG)	43.0
Polishing pond No. 2 (9.5 MMG)	9.5
Total system (days) (50.567 MMG)	
BOD load, pounds/day/acre (approx. 23.6 acres)	251
Average temperature, °C	
Influent	29.6
Effluent	25.9
Average pH	
Influent	7.1
Pond 2	7.3
Effluent	7.9
Average dissolved oxygen - mg/l	
Aeration pond	6.0
Settling pond	1.7
Polishing pond No. 1	2.4
Polishing pond No. 2	2.9
Return sludge	2.4
Nitrogen	
Average influent concentration, mg/l	3.2
Average dosage added, mg/l	2.8
Total influent concentration, mg/l	6.0
Total nitrogen - influent - pounds	5,039
Total nitrogen - effluent - pounds	3,275
Nitrogen removed - percent	35.0
Total gallons ammonia used	1,995

TABLE 16
(continued)

SUMMARY OF OPERATIONS 5 MGD FLOW RATE
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

Phosphorus

Average influent concentration, mg/l	0.9
Average dosage added, mg/l	0
Total influent concentration, mg/l	0.9
Total phosphorus - influent - pounds	756
Total phosphorus - effluent - pounds	588
Phosphorus removed - percent	22.2
Total gallons H_3PO_4 used	0

BOD:N

22.3:1

BOD:P

148:1

BOD:N:P

100:4.5:07

Total rainfall - inches

1.8

TABLE 17

SUMMARY OF OPERATIONS 10 MGD FLOW RATE

THE COCA-COLA COMPANY FOODS DIVISION

AUBURNDALE, FLORIDA

Total influent flow, MG	237.5
Average daily influent flow, MG	9.5
Average daily sludge recirculated, MG	10.4
Average percent sludge recirculated	108.4
Total pounds BOD - influent	295,325
Total pounds BOD - effluent	47,800
Average daily BOD - influent - mg/l	149
Average daily BOD - effluent - mg/l	24
Average BOD removal - percent	83.8
Total pounds COD - influent	445,300
Total pounds COD - effluent	157,825
Average daily COD - influent - mg/l	225
Average daily COD - effluent - mg/l	80
Average COD removal - percent	64.6
COD/BOD influent - average	1.5
COD/BOD effluent - average	3.3
Total pounds suspended solids - influent	39,615
Total pounds suspended solids - effluent	51,500
Average suspended solids - influent - mg/l	20
Average suspended solids - effluent - mg/l	26
Average total pounds MLSS (aeration basin)	5,500
Average MLSS, mg/l	68
Average pounds BOD/pound MLSS	2.1:1
Total hours aeration	3,473.8
Total pounds oxygen (3.5 lbs O ₂ /HP theoretical)	911,873
Pounds of oxygen / pounds of BOD applied	3.4
BOD load - pounds/day/HP (ave)	27.2
COD load - pounds/day/HP (ave)	41.0
Pounds of oxygen / pound of COD applied	2.2

TABLE 17
(continued)

SUMMARY OF OPERATIONS 10 MGD FLOW RATE
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

Detention time - hours (average)	
Aeration (9.7 MMG)	24.5
Settling (20.8 MMG)	52.5
Sludge removal section (9.2 MMG)	23.2
Polishing pond No. 1 (10.5 MMG)	26.5
Polishing pond No. 2 (9.5 MMG)	24.0
Total system (days) (20.567 MMG)	5.3
BOD load, pounds/day/acre (approx. 23.6 acres)	500
Average temperature, ° C	
Influent	33.1
Effluent	28.7
Average pH	
Influent	7.0
Pond 2	7.1
Effluent	7.3
Average dissolved oxygen - mg/l	
Aeration pond	4.9
Settling pond	1.3
Polishing pond No. 1	1.5
Polishing pond No. 2	1.5
Return sludge	1.7
Nitrogen	
Average influent concentration, mg/l	4.5
Average dosage added, mg/l	2.8
Total influent concentration, mg/l	7.3
Total nitrogen - influent - pounds	14,459
Total nitrogen - effluent - pounds	4,952
Nitrogen removed - percent	65.8
Total gallons ammonia used	2.625

TABLE 17
(continued)

SUMMARY OF OPERATIONS 10 MGD FLOW RATE
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

Phosphorus

Average influent concentration, mg/l	1.48
Average dosage added, mg/l	.02
Total influent concentration, mg/l	1.5
Total phosphorus - influent - pounds	2,971
Total phosphorus - effluent - pounds	792
Phosphorus removed - percent	73.3
Total gallons H_3PO_4 used	75
BOD:N	20.4:1
BOD:P	99.0:1
BOD:N:P	100:4.9:1.0
Total rainfall - inches	1.6

TABLE 18
SUMMARY OF AVERAGE MONTHLY OPERATIONS (1)
1968-69 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

PARAMETER	DECEMBER	JANUARY	FEBRUARY	MARCH (2)	MAY (3)	JUNE (4)	AVERAGE	MAXIMUM	MINIMUM
TOTAL INFILTRANT FLOW - MGD	401.86	437.21	501.20	322.40	188.40	444.00	384.18	501.20	188.40
AVERAGE INFILTRANT FLOW - MGD	12.96	14.10	17.80	10.40	6.40	14.00	12.76	17.80	6.40
AVERAGE SLUDGE RECIRCULATED - MGD	11.55	10.77	4.30	3.00	6.90	8.80	7.52	11.55	3.00
AVERAGE PERCENT SLUDGE RECIRCULATED	95.0	76.4	24.0	28.8	108.0	58.2	65.1	108.0	24.0
TOTAL POUNDS BOD - INFILTRANT	359612	536014	385840	175057	210056	491460	358673	538014	175057
TOTAL POUNDS BOD - EFFLUENT	132326	171379	138376	44733	18290	125010	105019	171379	18290
AVERAGE DAILY BOD - INFILTRANT - MG/L	109	147	120	65	127	133	117	147	65
AVERAGE DAILY BOD - EFFLUENT - MG/L	39	47	39	17	11	34	31	47	11
AVERAGE BOD REMOVAL - PERCENT	64.2	68.0	67.5	73.8	91.3	74.6	73.2	91.3	64.1
TOTAL POUNDS COD - INFILTRANT	573717	858994	794416	353834	314650	774180	611282	858994	314650
TOTAL POUNDS COD - EFFLUENT	318851	437563	418360	171647	84692	346300	295902	437563	84692
AVERAGE DAILY COD - INFILTRANT - MG/L	172	235	189	132	180	209	180	235	132
AVERAGE DAILY COD - EFFLUENT - MG/L	92	120	100	64	51	94	87	120	51
AVERAGE COD REMOVAL - PERCENT	46.5	48.9	46.7	51.5	73.1	55.0	54.1	73.1	46.5
COD / BOD INFILTRANT	1.73	1.80	2.16	2.00	1.50	1.60	1.78	2.10	1.50
COD / BOD EFFLUENT	2.80	2.55	3.00	3.80	4.60	2.80	3.26	4.60	2.55
TOTAL POUNDS SUSPENDED SOLIDS - INFILTRANT	87141	138562	67956	83049	35402	75990	81335	138562	35402
TOTAL POUNDS SUSPENDED SOLIDS - EFFLUENT	87185	127622	20980	63736	22289	109080	72979	127622	20980
AVERAGE SUSPENDED SOLIDS - INFILTRANT - MG/L	26	38	17	31	21	20	26	38	20
AVERAGE SUSPENDED SOLIDS - EFFLUENT - MG/L	29	35	28	24	13	28	26	35	13
AVERAGE TOTAL POUNDS MLSS (AERATION BASIN)	3317	4448	8332	5339	4854	5500	5299	8332	3317
AVERAGE MLSS - MG/L	41	55	103	66	60	68	66	103	41
AVERAGE POUNDS BOD / POUND MLSS	3.5	3.8	1.7	1.0	1.4	3.0	2.4	3.8	1.0
TOTAL HOURS AERATION	2486	3816	4020	2879	4213	4187	3804	4213	2486
TOTAL POUNDS OXYGEN (3.5 LBS O ₂ /M ³ P. THEORETICAL)	655200	1001700	855330	755738	1105913	1101713	945930	1105913	655200
POUNDS OF OXYGEN/POUND OF BOD APPLIED	1.83	1.87	2.74	4.30	5.26	2.74	3.04	5.26	1.83
BOD LOAD - POUNDS/DAY/M ²	46.0	44.7	30.7	19.5	15.8	37.5	32.4	46.0	15.8
COD LOAD - POUNDS/DAY/M ²	73.5	71.8	63.2	39.3	23.9	59.0	55.1	73.5	23.9
POUNDS OF OXYGEN / POUND OF COD APPLIED	1.14	1.17	1.33	2.10	3.50	1.42	1.76	3.50	1.14
DETENTION TIME - HOURS									
AERATION BASIN	18.0	16.4	13.0	22.4	36.4	15.7	20.3	36.4	13.0
SETTLING BASIN	38.5	35.4	27.8	48.0	78.0	33.7	43.6	78.0	27.8
SLUDGE REMOVAL SECTION	17.0	15.6	12.3	21.2	34.5	14.9	19.3	34.5	12.3
POLISHING POND NO. 1	18.4	18.0	14.1	24.2	38.4	17.0	22.0	38.4	14.1
POLISHING POND NO. 2	17.6	16.2	12.7	21.9	35.6	15.4	19.8	35.6	12.7
TOTAL SYSTEM - DAYS	3.9	3.6	2.8	4.9	7.9	3.4	4.4	7.9	2.8
BOD LOAD - POUNDS/DAY/ACRE	482	733	584	239	287	694	505	733	239
TEMPERATURE °C									
INFILTRANT	25.4	27.7	25.8	23.4	26.8	33.0	27.4	33.0	23.4
EFFLUENT	22.8	22.7	20.6	18.5	25.6	30.4	23.6	30.4	18.5

AERATION BASIN	18.0	16.4	13.9	22.4	28.4	18.7	28.9	38.1	12.9
SETTLING BASIN	30.5	35.4	27.9	48.0	78.0	33.7	43.6	78.0	27.9
SLUDGE REMOVAL SECTION	17.0	15.6	12.3	21.2	34.5	14.9	19.3	34.5	12.3
POLISHING POND NO. 1	19.4	18.0	14.1	24.7	38.4	17.0	22.0	39.4	14.1
POLISHING POND NO. 2	17.6	16.2	12.7	21.9	35.6	15.4	19.9	35.6	12.7
TOTAL SYSTEM - DAYS	3.9	3.6	2.8	4.9	7.9	3.4	4.4	7.9	2.8
ROD LOAD - POUNDS/DAY/ACRE	492	733	584	239	287	994	505	733	239
TEMPERATURE °C									
INFLUENT	25.4	27.7	25.8	23.4	28.8	33.0	27.4	33.0	23.4
EFFLUENT	22.8	22.7	20.6	18.5	25.6	30.4	23.6	30.4	19.5
pH									
INFLUENT	7.0	7.2	7.0	7.3	7.1	7.1	7.1	7.3	7.0
POND 2	7.1	7.1	7.1	7.2	7.3	6.9	7.1	7.3	6.9
EFFLUENT	7.1	7.1	7.1	7.3	7.7	7.1	7.2	7.7	7.1
DISSOLVED OXYGEN - mg/l									
AERATION POND	3.4	3.2	3.4	5.3	5.7	4.4	4.2	5.7	3.2
SETTLING POND	1.7	0.4	0.5	2.0	1.6	1.2	1.2	2.0	0.4
POLISHING POND NO. 1	0.6	0.1	0.4	2.0	2.1	1.4	1.1	2.1	0.1
POLISHING POND NO. 2	2.8	0.6	0.9	2.9	2.5	1.2	1.8	2.6	0.8
RETURN SLUDGE	1.1	0.7	1.4	2.4	2.2	1.7	1.6	2.4	0.7
NITROGEN									
INFLUENT CONCENTRATION, mg/l	2.84	1.60	2.46	2.82	3.35	4.56	3.05	4.56	1.60
DOSAGE ADDED, mg/l	2.86	2.80	2.84	2.13	2.90	2.83	2.68	2.84	2.13
TOTAL INFLUENT CONCENTRATION, mg/l	5.52	4.40	5.30	4.95	6.15	7.39	5.73	7.39	4.40
TOTAL NITROGEN - INFLUENT - POUNDS	18461	16040	22154	13310	10281	25928	17691	25920	10281
TOTAL NITROGEN - EFFLUENT - POUNDS	12374	18586	12540	10943	5610	13700	12784	18586	5610
NITROGEN REMOVAL - PERCENT	33.0	0	43.3	17.8	45.3	47.1	30.5	47.1	0
TOTAL GALLONS AMMONIA USED	2821	3255	2940	2100	3255	3150	2920	3255	2100
PHOSPHOROUS									
INFLUENT CONCENTRATION, mg/l	0.78	0.54	0.58	0.81	1.01	0.87	0.78	1.01	0.54
DOSAGE ADDED, mg/l	0.33	0.59	0.66	0.44	0.15	0.20	0.42	0.68	0.15
TOTAL INFLUENT CONCENTRATION, mg/l	1.01	1.13	1.24	1.35	1.16	1.07	1.16	1.37	1.00
TOTAL PHOSPHOROUS - INFLUENT - POUNDS	3378	3829	4691	3630	1084	3703	3569	4881	1084
TOTAL PHOSPHOROUS - EFFLUENT - POUNDS	2207	2370	2926	3146	892	2222	2311	3146	892
PHOSPHOROUS REMOVAL - PERCENT	34.7	38.1	40.2	13.3	50.0	40.0	36.1	50.0	13.3
TOTAL GALLONS H ₂ PO ₄ USED	70	378	392	280	119	120	227	392	70
800-N	19.7	33.4	19.6	13.1	20.5	19.0	20.9	33.4	13.1
800-P	118	130	88.2	46.1	106	133	104	133	46.1
800-N-P	100:5.9:1.1	100:3:0.46	100:5.4:1.3	100:7.6:2.1	100:4.9:0.9	100:5.3:0.7	100:4.8:1.0	100:7.6:2.1	100:3:0.46
TOTAL RAINFALL - INCHES	0	3.5	1.7	6.7	2.0	4.6	18.5	6.7	0

(1) NO DATA COLLECTED APRIL, 1969. - DATA FOR NOVEMBER NOT INCLUDED ADAMS' STARTUP-15 DAYS OPERATION.
 (2) MINIMUM PROCESSING - CHANGE OVER TO VALENCIAS
 (3) CONTROLLED INFLUENT FLOW MAY 1-19. ± 5 mgd.
 (4) CONTROLLED INFLUENT FLOW MAY 20 - JUNE 13. ± 10 mgd.
 (5) TOTAL RAINFALL FOR PERIOD.

TABLE 1.9
SUMMARY OF NITROGEN AND PHOSPHORUS ANALYSES
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

SAMPLE DATE	CITRUS WASTEWATER - INFLUENT - mg/l										SETTLING POND EFFLUENT - mg/l										FINAL EFFLUENT - mg/l															
	NITROGEN AS N					TOTAL P _Q -P					NITROGEN AS N					TOTAL P _Q -P					NITROGEN AS N					TOTAL P _Q -P										
	NH ₃	ORG.	NO ₂	NO ₃	NH ₃ ADDED	TOTAL	WAT.	DOSED	NH ₃	ORG.	NO ₂	NO ₃	TOTAL	NH ₃	ORG.	NO ₂	NO ₃	TOTAL	NH ₃	ORG.	NO ₂	NO ₃	TOTAL	NH ₃	ORG.	NO ₂	NO ₃	TOTAL	NH ₃	ORG.	NO ₂	NO ₃	TOTAL			
1966																																				
DEC 4	0.24	2.96	0.001	0.09	1.43	4.74	1.84	1.84	2.43	10.26	0	0	12.69	0	2.30	0.008	0	2.30	0	2.30	0.008	0	0	2.30	0	2.30	0.008	0	0	2.30	0	2.30	0	2.30	0	2.30
DEC 13	0.34	1.92	0.012	0.08	2.84	5.19	0.66	0.66	0	3.14	0.003	0.03	3.17	0	3.46	0.002	0.01	3.47	0	3.46	0.002	0.01	0	3.47	0	3.46	0.002	0.01	0	3.47	0	3.47	0	3.47	0	3.47
DEC 18	0.57	1.43	0.020	0	2.84	4.86	0.58	0.58	0	4.37	0.003	0.03	4.40	0	4.11	0.002	0.04	4.15	0	4.11	0.002	0.04	0	4.15	0	4.11	0.002	0.04	0	4.15	0	4.15	0	4.15	0	4.15
DEC 26	0.79	1.49	0.018	0.06	2.84	5.20	0.60	1.19	0.66	4.48	0.002	0.05	5.19	0	4.15	0.002	0.03	4.18	0	4.15	0.002	0.03	0	4.18	0	4.15	0.002	0.03	0	4.18	0	4.18	0	4.18	0	4.18
DEC 31	0.40	2.74	0.014	0	2.84	7.00	0.21	0.80	0.07	4.06	0.002	0	4.13	0	4.08	0.001	0	4.10	0	4.08	0.001	0	0	4.10	0	4.08	0.001	0	0	4.10	0	4.10	0	4.10	0	4.10
1967																																				
JAN 7	0.08	1.30	0.010	0.21	2.80	4.40	0.54	1.13	0	4.83	0.022	0.18	5.01	0	4.92	0.005	0.22	5.14	0	4.92	0.005	0.22	0	5.14	0	4.92	0.005	0.22	0	5.14	0	5.14	0	5.14	0	5.14
FEB 6	0	1.68	0	0.07	2.84	4.59	0.40	1.13	0	3.75	0	0.05	3.80	0	3.58	0	0.03	3.61	0	3.58	0	0.03	0	3.61	0	3.58	0	0.03	0	3.61	0	3.61	0	3.61	0	3.61
FEB 9	0	1.86	0.003	0.11	2.84	4.81	0.47	1.20	0.69	5.06	0.003	0	5.57	0	3.00	0	0	3.00	0	3.00	0	0	0	3.00	0	3.00	0	0	0	3.00	0	3.00	0	3.00	0	3.00
FEB 19	0	2.48	0.002	0.22	2.80	6.50	0.80	1.40	0	4.18	0.001	0.11	4.29	0	3.39	0	0.10	3.49	0	3.39	0	0.10	0	3.49	0	3.39	0	0.10	0	3.49	0	3.49	0	3.49	0	3.49
FEB 25	0	2.30	0.004	0.10	2.80	5.20	0.63	1.22	0	2.34	0	0	2.34	0	2.09	0	0	2.09	0	2.09	0	0	0	2.09	0	2.09	0	0	0	2.09	0	2.09	0	2.09	0	2.09
MAR 4	0	2.97	0.001	0.08	2.85	5.90	1.03	1.62	0.59	4.57	0.001	0.01	5.17	0	2.75	0.001	0	2.76	0	2.75	0.001	0	0	2.76	0	2.75	0.001	0	0	2.76	0	2.76	0	2.76	0	2.76
MAR 11	0.48	2.06	0.012	0.06	2.80	5.51	0.94	1.53	2.34	3.15	0	0	5.49	0	4.70	0	0	4.70	0	4.70	0	0	0	4.70	0	4.70	0	0	0	4.70	0	4.70	0	4.70	0	4.70
MAR 18	0	2.58	0.002	0.19	2.83	5.60	0.96	1.55	0	4.04	0	0.01	4.05	0	3.41	0.001	0.07	4.12	0	3.41	0.001	0.07	0	4.12	0	3.41	0.001	0.07	0	4.12	0	4.12	0	4.12	0	4.12
MAR 24	0	2.66	0.002	0.17	2.83	5.83	0.70	0.70	0.82	3.45	0.001	0.04	4.31	0	2.31	0.005	0.31	2.83	0	2.31	0.005	0.31	0	2.83	0	2.31	0.005	0.31	0	2.83	0	2.83	0	2.83	0	2.83
MAY 5	0	2.66	0.004	0.36	2.84	6.06	1.14	1.14	0.82	3.50	0.002	0.33	4.45	0	1.51	0.005	0.38	5.81	0	1.51	0.005	0.38	0	5.81	0	1.51	0.005	0.38	0	5.81	0	5.81	0	5.81	0	5.81
MAY 12	0	3.02	0.004	0.51	2.84	6.37	0.85	0.85	0	0	0	0	0	0	2.45	0.009	0.40	3.19	0	2.45	0.009	0.40	0	3.19	0	2.45	0.009	0.40	0	3.19	0	3.19	0	3.19	0	3.19
MAY 19	0	2.43	0.007	0.41	2.84	5.69	0.77	0.77	1.03	4.84	0.003	0.41	6.08	0	1.89	0	0.12	2.01	0	1.89	0	0.12	0	2.01	0	1.89	0	0.12	0	2.01	0	2.01	0	2.01	0	2.01
MAY 26	0	3.55	0.001	0.26	2.84	6.65	1.29	1.88	0	4.81	0.001	0.14	4.95	0	2.67	0.001	0.07	2.84	0	2.67	0.001	0.07	0	2.84	0	2.67	0.001	0.07	0	2.84	0	2.84	0	2.84	0	2.84
JUN 2	0	4.87	0.001	0.16	2.84	7.87	0.55	1.14	0.26	2.00	0.001	0.18	2.46	0	4.21	0	0.01	4.22	0	4.21	0	0.01	0	4.22	0	4.21	0	0.01	0	4.22	0	4.22	0	4.22	0	4.22
JUN 16	0	2.68	0.002	0.07	2.84	5.59	0.73	0.73	0	5.05	0	0.03	5.08	0	3.65	0.002	0.05	3.90	0	3.65	0.002	0.05	0	3.90	0	3.65	0.002	0.05	0	3.90	0	3.90	0	3.90	0	3.90
JUN 20	0.11	3.04	0.003	0.09	2.84	6.08	0.73	0.73	0.39	3.72	0.003	0.05	4.16	0	3.63	0.001	0.05	3.68	0	3.63	0.001	0.05	0	3.68	0	3.63	0.001	0.05	0	3.68	0	3.68	0	3.68	0	3.68
JUN 23	3.26	2.31	0.001	0.07	2.84	8.48	1.34	1.34	1.11	3.66	0.001	0.08	4.84	0	3.37	0.002	0.08	3.64	0	3.37	0.002	0.08	0	3.64	0	3.37	0.002	0.08	0	3.64	0	3.64	0	3.64	0	3.64
AVERAGE	0.29	2.56	0.006	0.15	2.77	5.68	0.81	1.16	0.53	4.24	0.001	0.08	4.84	0	3.37	0.002	0.08	3.64	0	3.37	0.002	0.08	0	3.64	0	3.37	0.002	0.08	0	3.64	0	3.64	0	3.64	0	3.64
MAXIMUM	3.26	4.87	0.020	0.41	2.85	8.48	1.84	1.88	2.43	10.26	0.003	0.41	12.69	1.64	4.92	0.009	0.40	5.81	1.64	4.92	0.009	0.40	0	5.81	1.64	4.92	0.009	0.40	0	5.81	0	5.81	0	5.81	0	5.81
MINIMUM	0	1.30	0	0	1.43	2.63	0.21	0.58	0	2.00	0	0	2.34	0	1.89	0	0	2.01	0	1.89	0	0	0	2.01	0	1.89	0	0	0	2.01	0	2.01	0	2.01	0	2.01

TABLE 20
MONTHLY AVERAGE DATA
WASTEWATER TREATMENT PLANT
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA

Month (1968-69)	Flow mgd	BOD, mg/l		BOD, lbs/day		BOD Removal Percent	Temperature, °C			
		Inf.	Eff.	Inf.	Eff.		Ambient	Inf.	Pond 1	Pond 4
Nov. (1)	5.8	106	12	5,130	580	88.7	16.8(6)		22.3	17.2
Dec.	12.9	109	39	11,700	4,200	64.2	14.4(6)		25.4	22.8
Jan.	14.1	147	47	17,300	5,530	68.0	15.2(6)		27.7	22.7
Feb. (2)	17.9	120	39	17,900	5,820	67.5	13.9(6)		25.8	20.6
Mar. (3)	10.4	65	17	5,640	1,480	73.8	15.5(6)		22.4	18.7
Apr. (4)	6.4	127	11	6,780	587	91.3	21.3	32.7	28.8	25.6
May (5)	14.8	133	34	16,382	4,167	74.6	21.6	33.0	31.0	30.4
June	11.8(7)	124	28.4	11,547(7)	3,195(7)	72.3	17.0	32.9	26.2	22.6
Average (8)	26.6	250	126	49,474	19,743	98.4	34.2	35.6	32.2	32.0
Maximum (8)	0.8	14	2	782	38	20.9	15.0	27.8	20.0	15.0

- (1) 15 days only
- (2) Changeover, BOD values not included
- (3) No data collected
- (4) Plant influent flow controlled ± 5 mgd - May 1-19
- (5) Plant influent flow controlled ± 10 mgd - May 20 - June 13
- (6) Weather bureau data - Lake Alfred
- (7) Value not absolute due to intentional bypass during research and plant overloads
- (8) Maximum and minimum values are from daily operations during 1968-69 citrus processing season

FIGURE 1

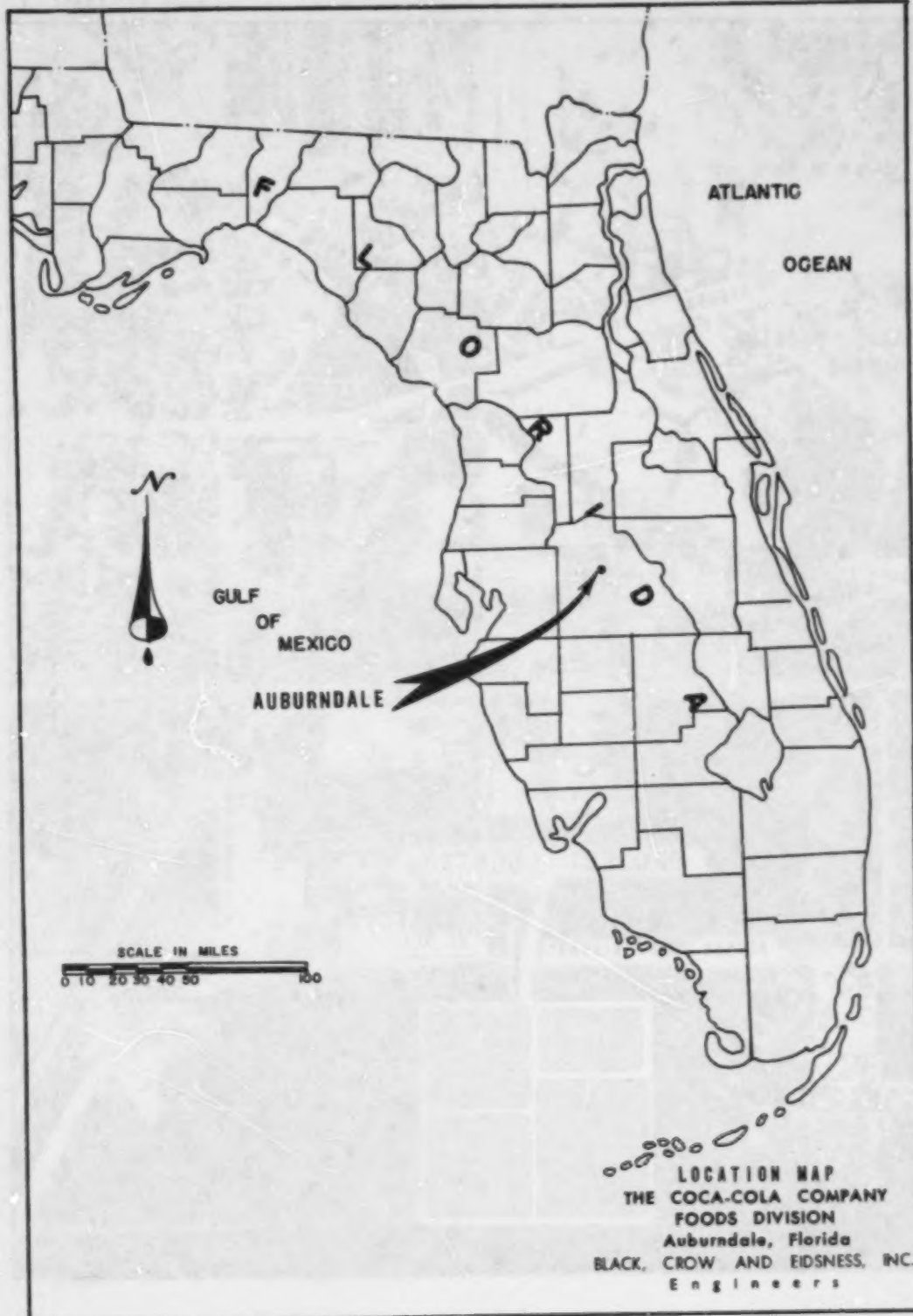


FIGURE 2

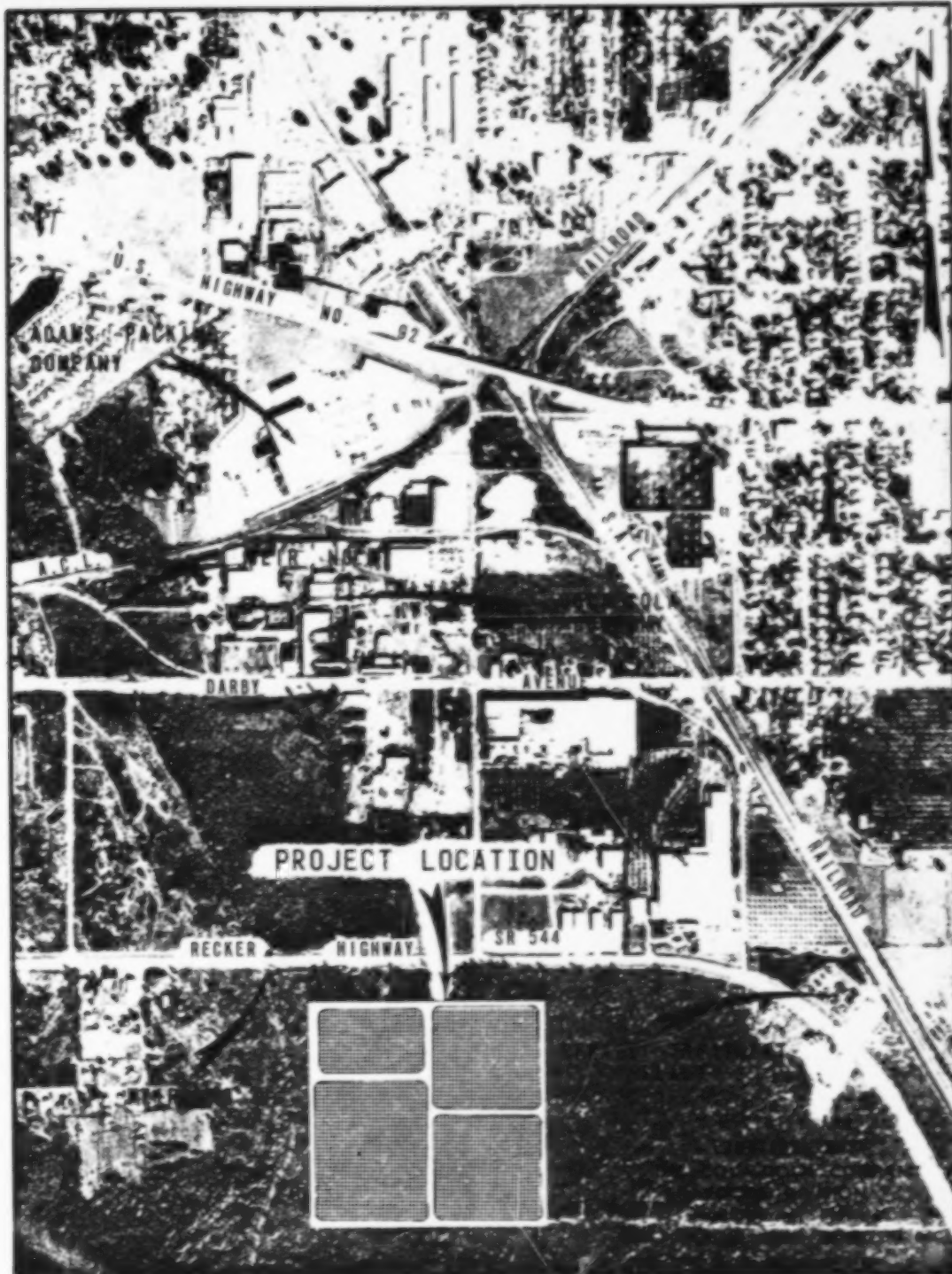


FIGURE 3

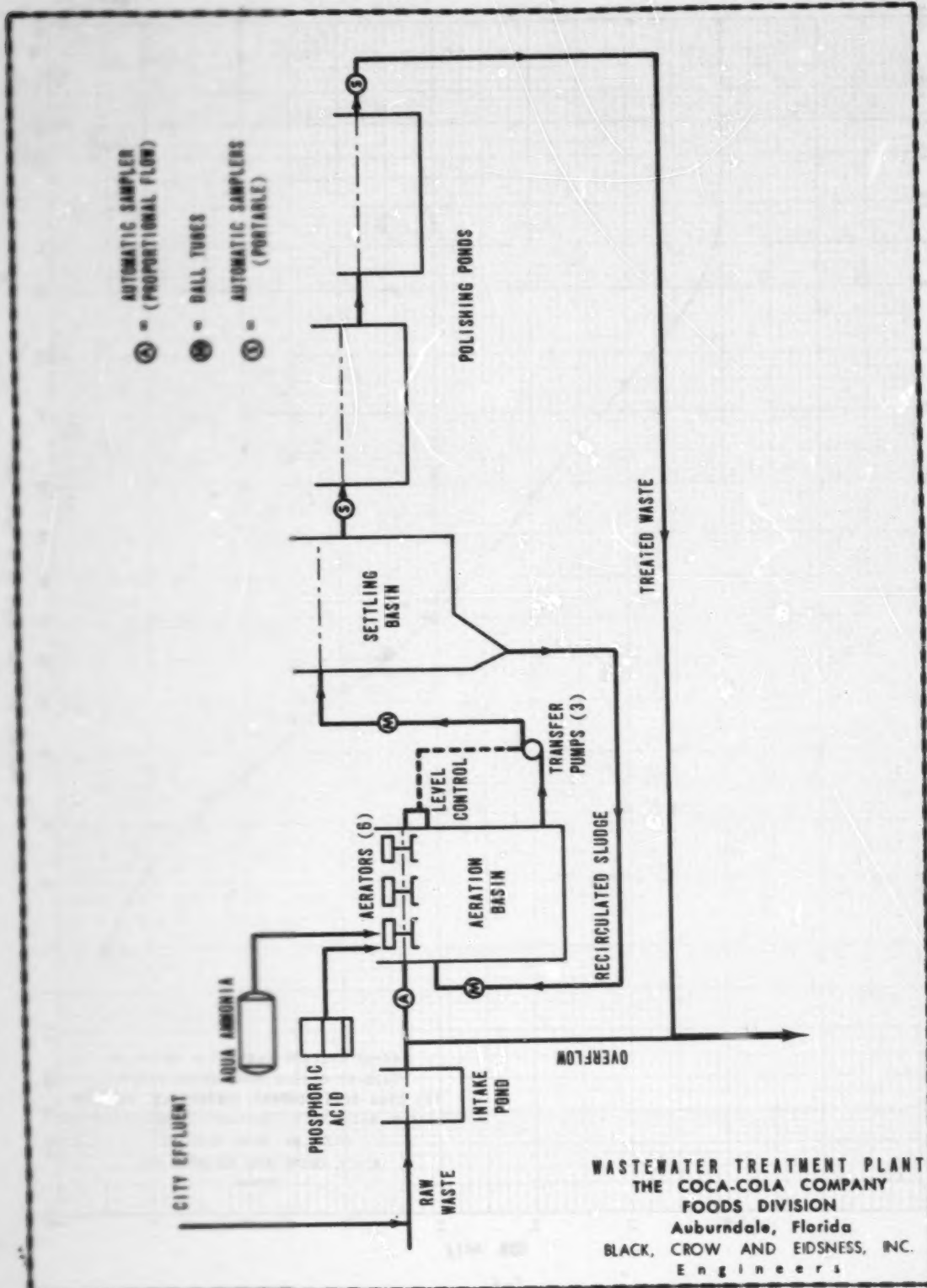
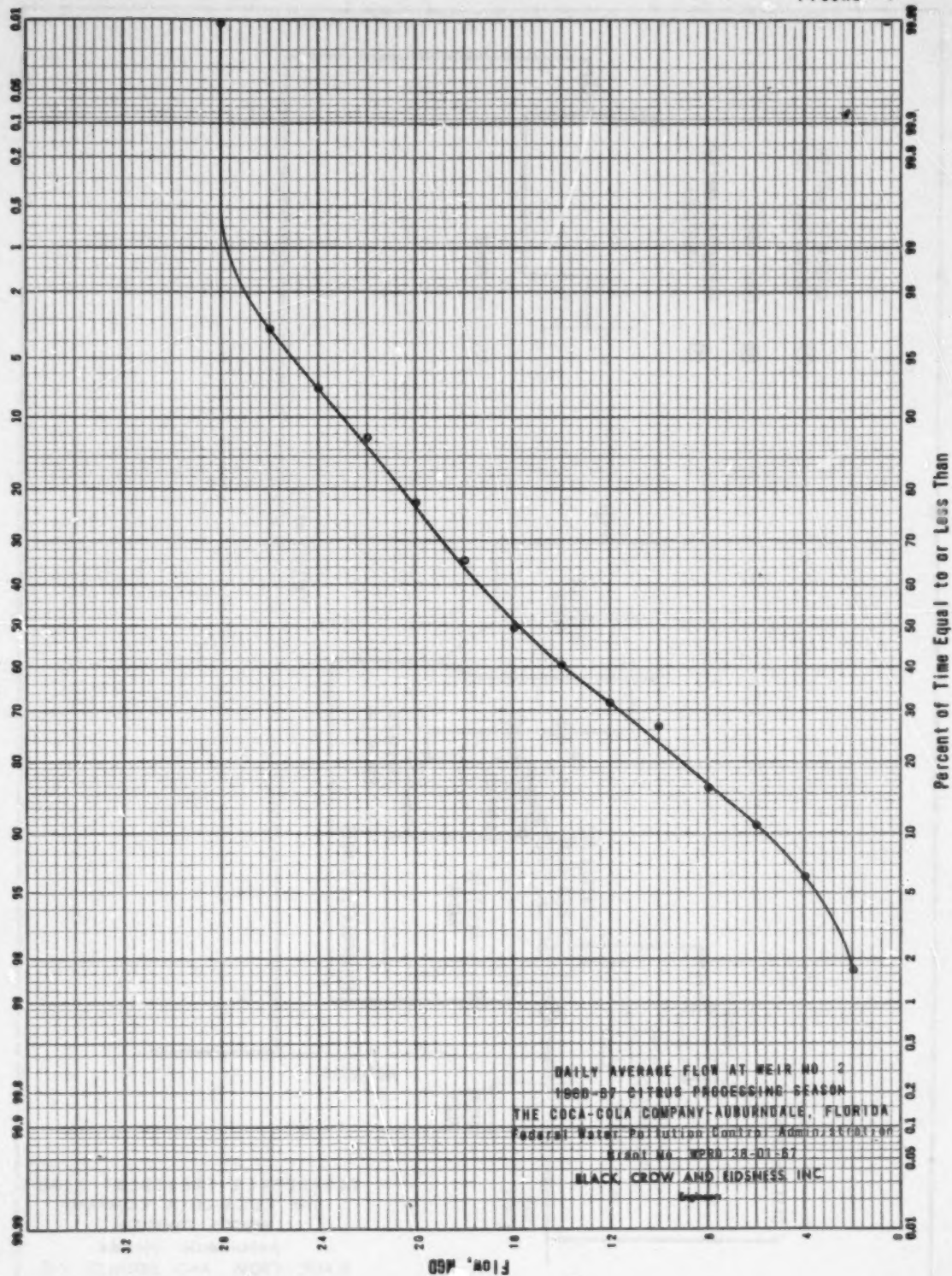


FIGURE 4



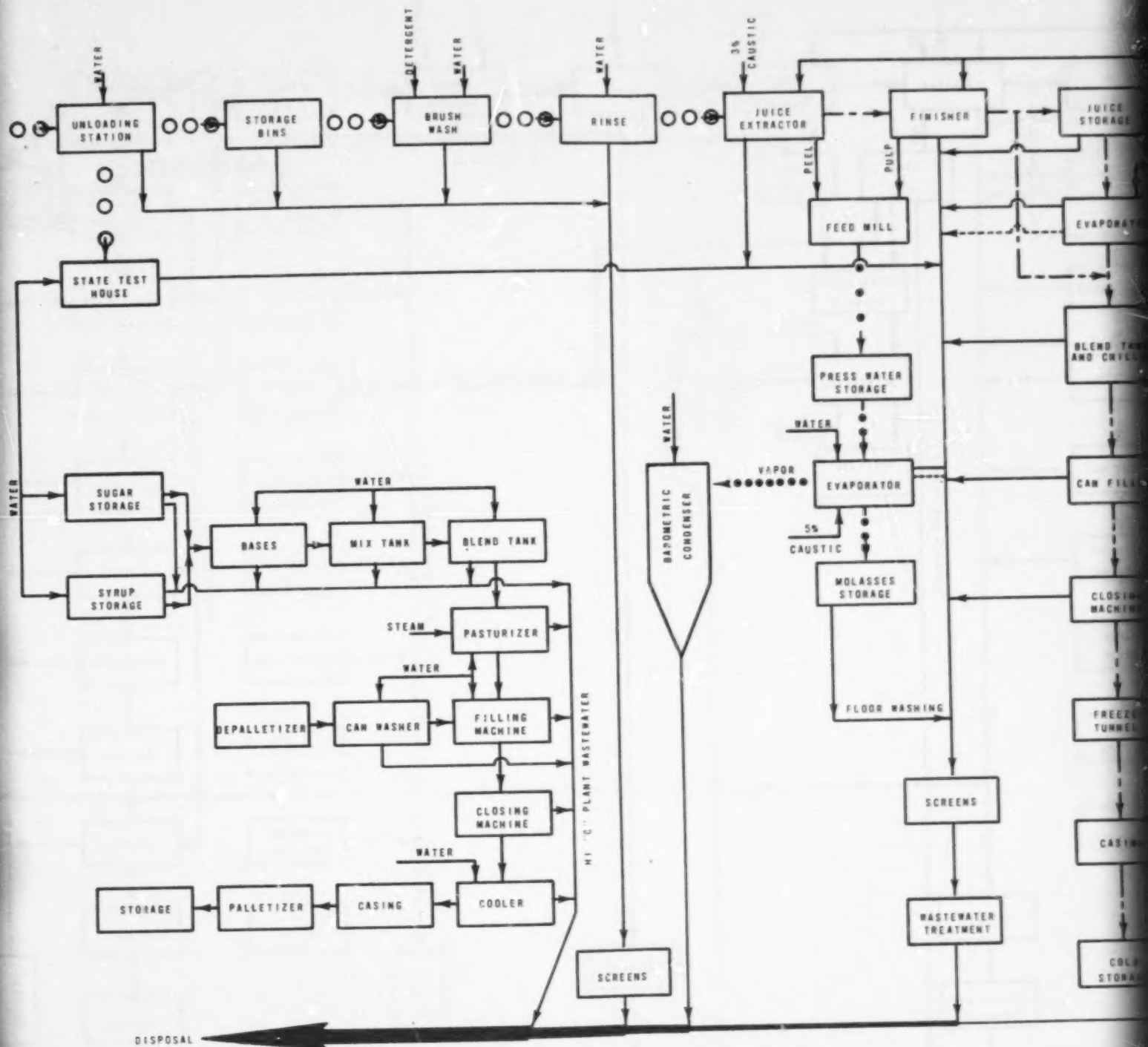
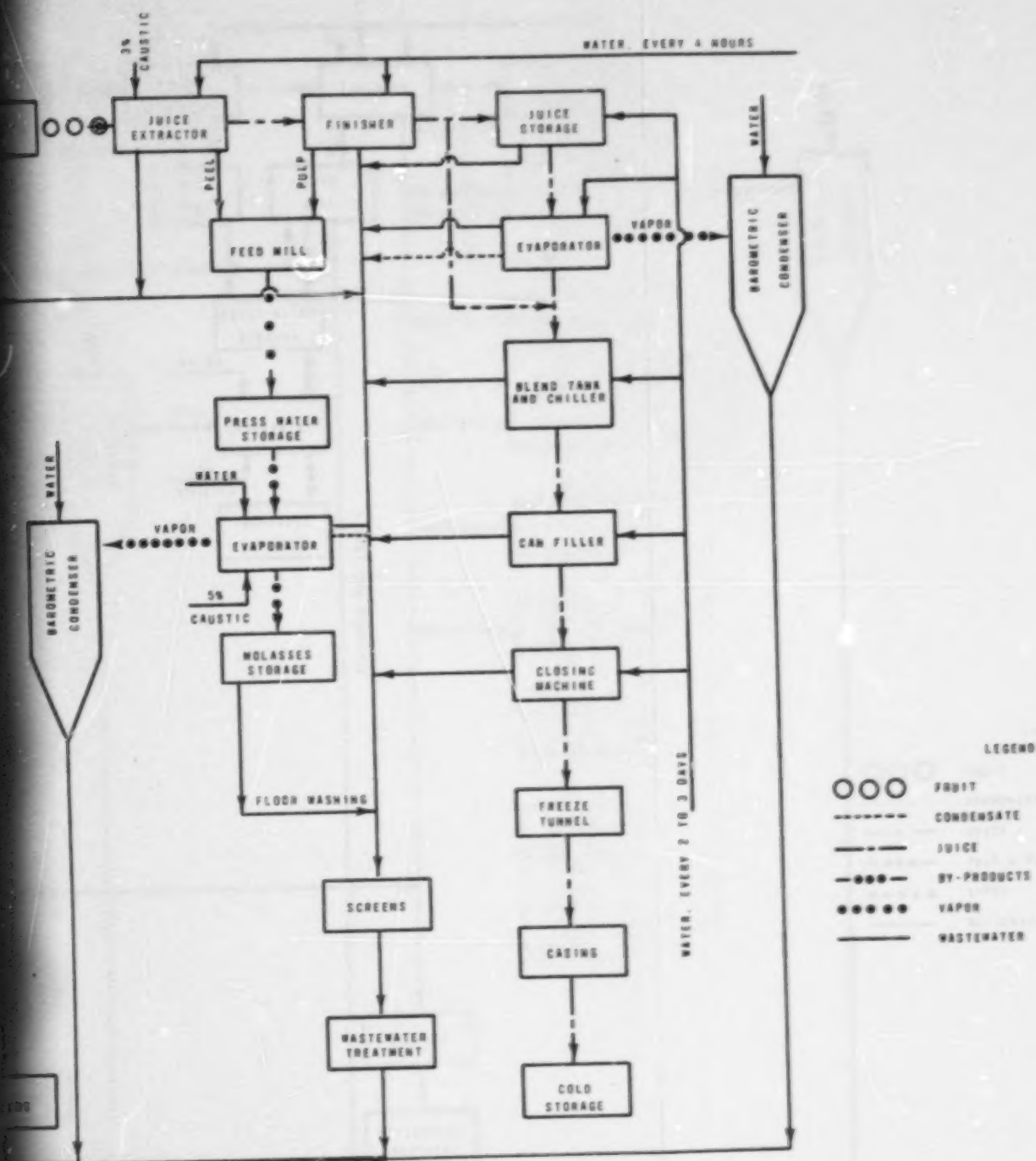
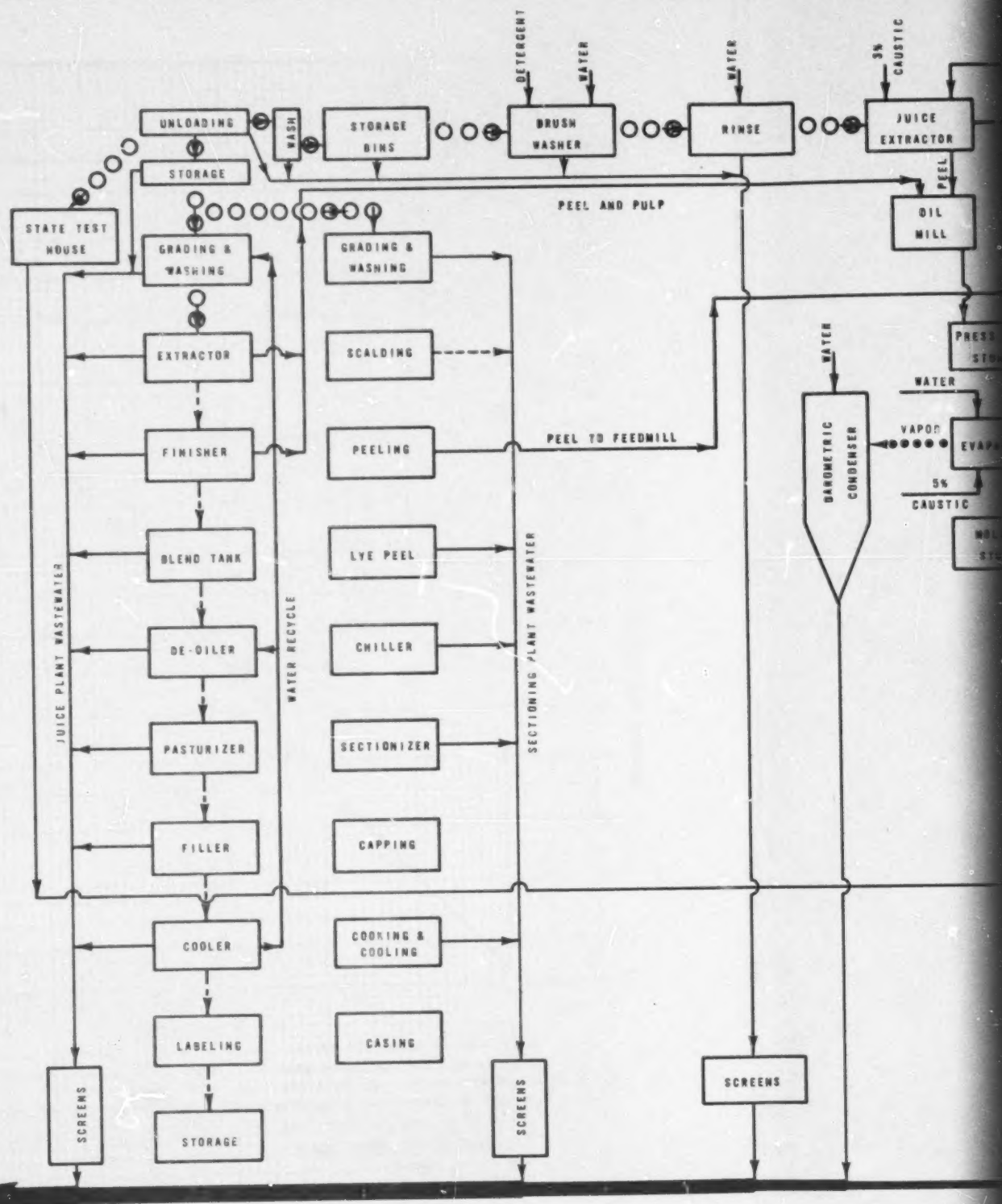
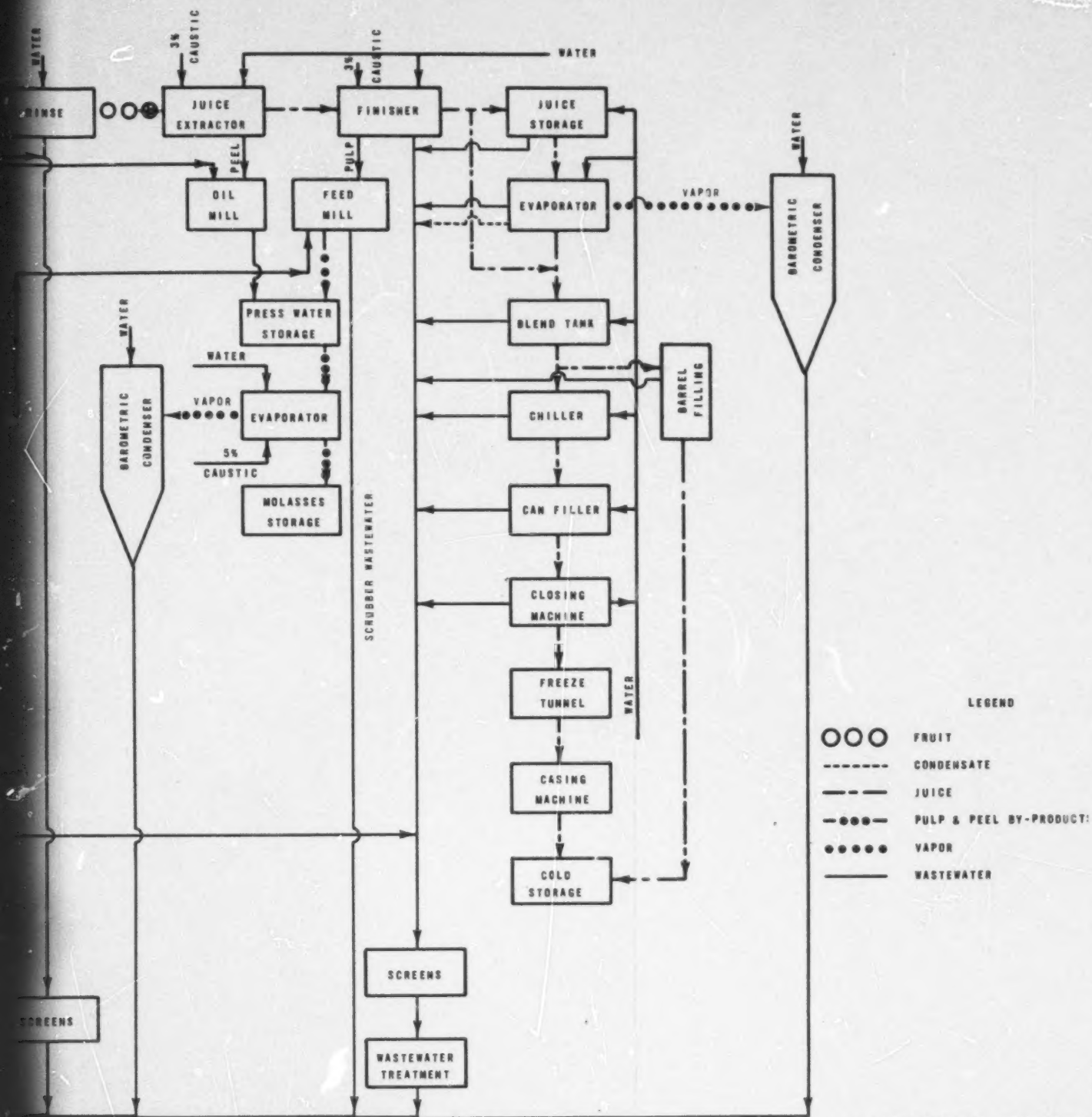


FIGURE 3a



WASTEWATER SOURCES
CITRUS CONCENTRATE PLANT AND HI "C" PLANT
THE COCA-COLA COMPANY
FOODS DIVISION
Auburndale, Florida
BLACK, CROW AND EIDNESS, INC.
Engineers





WASTEWATER SOURCES
 ADAMS PACKING COMPANY
 THE COCA-COLA COMPANY
 FOODS DIVISION
 Auburndale, Florida
 BLACK, CROW AND EIDSNES, INC.
 Engineers

FIGURE 5

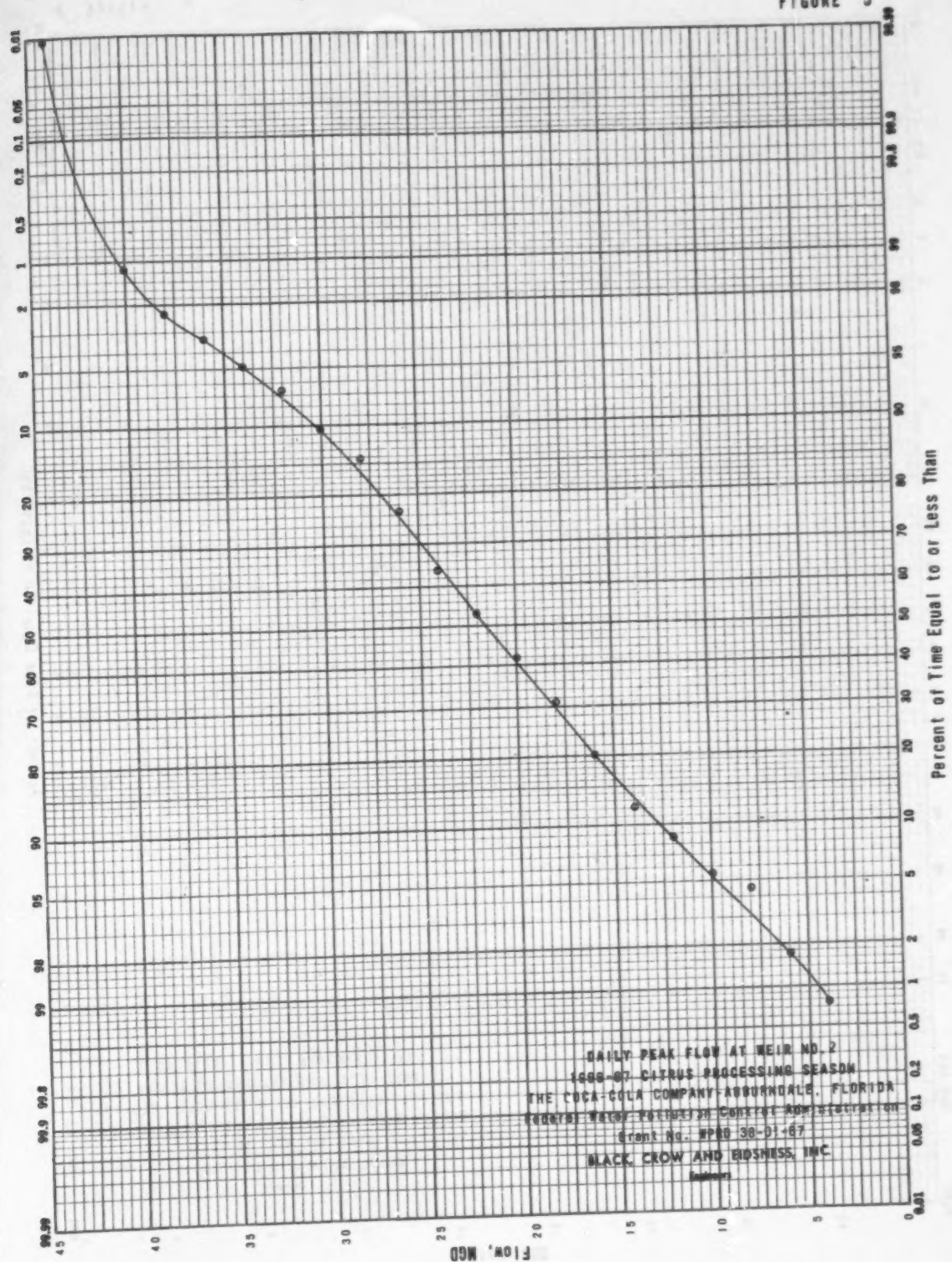


FIGURE 6

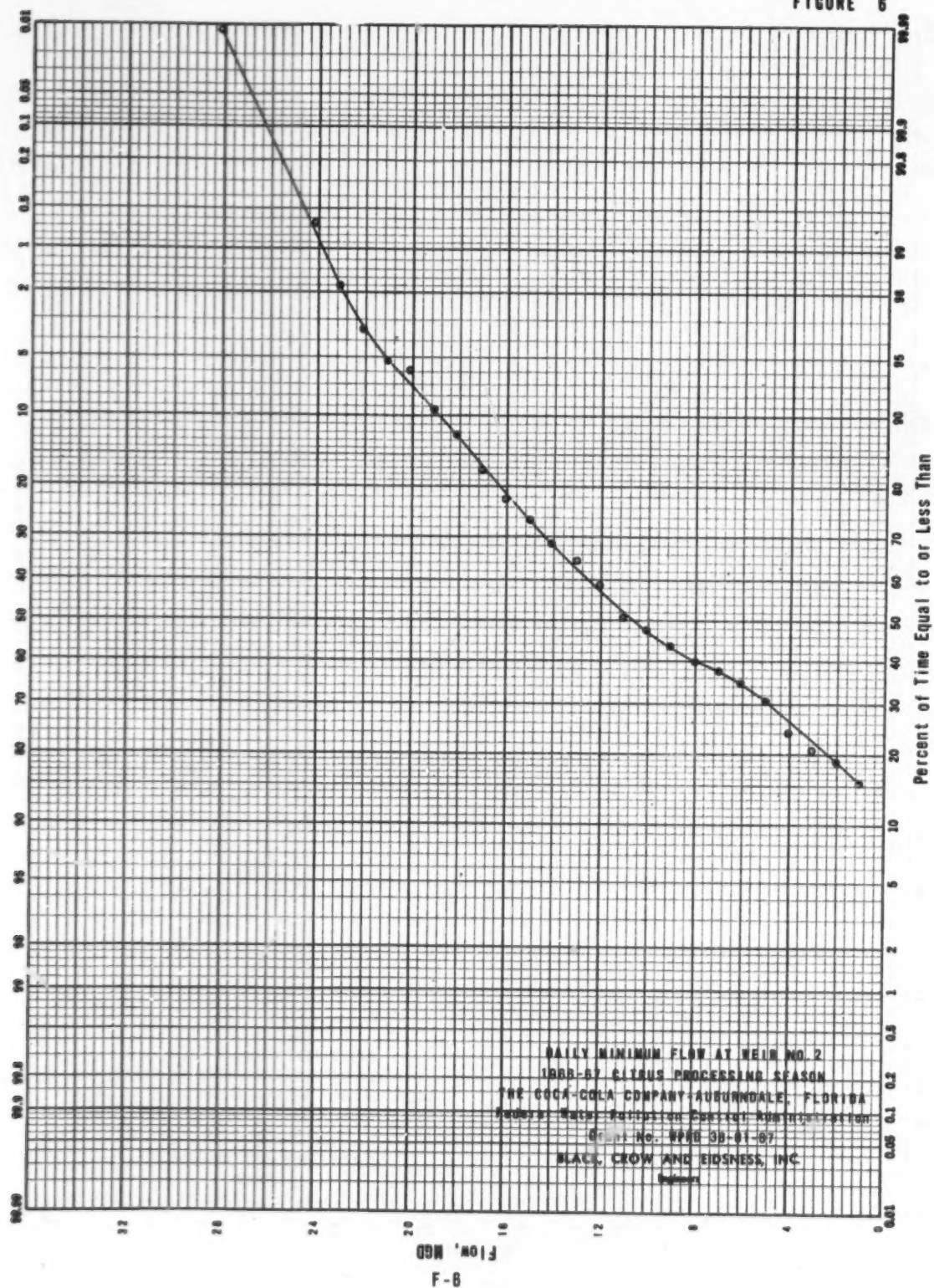
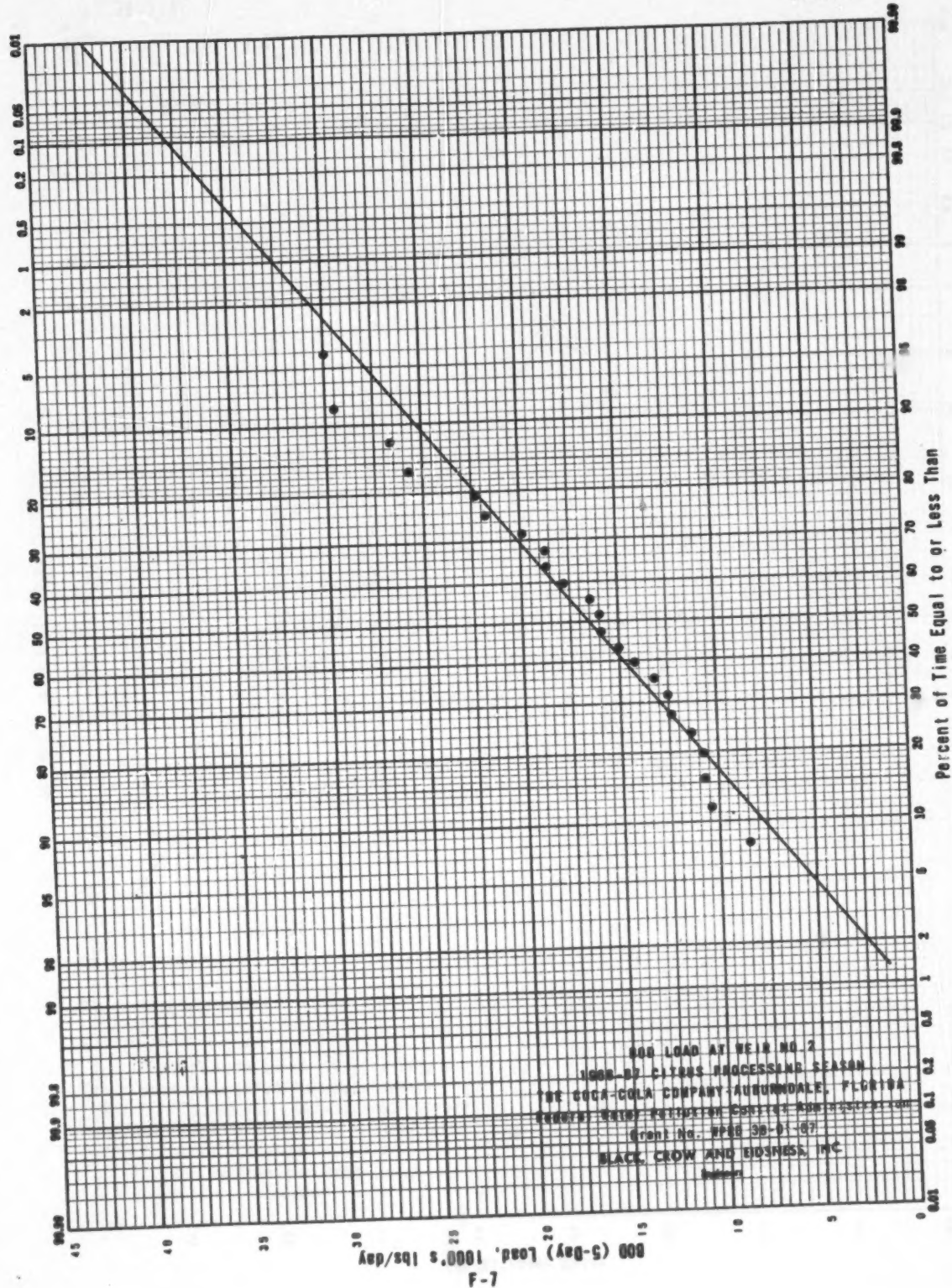
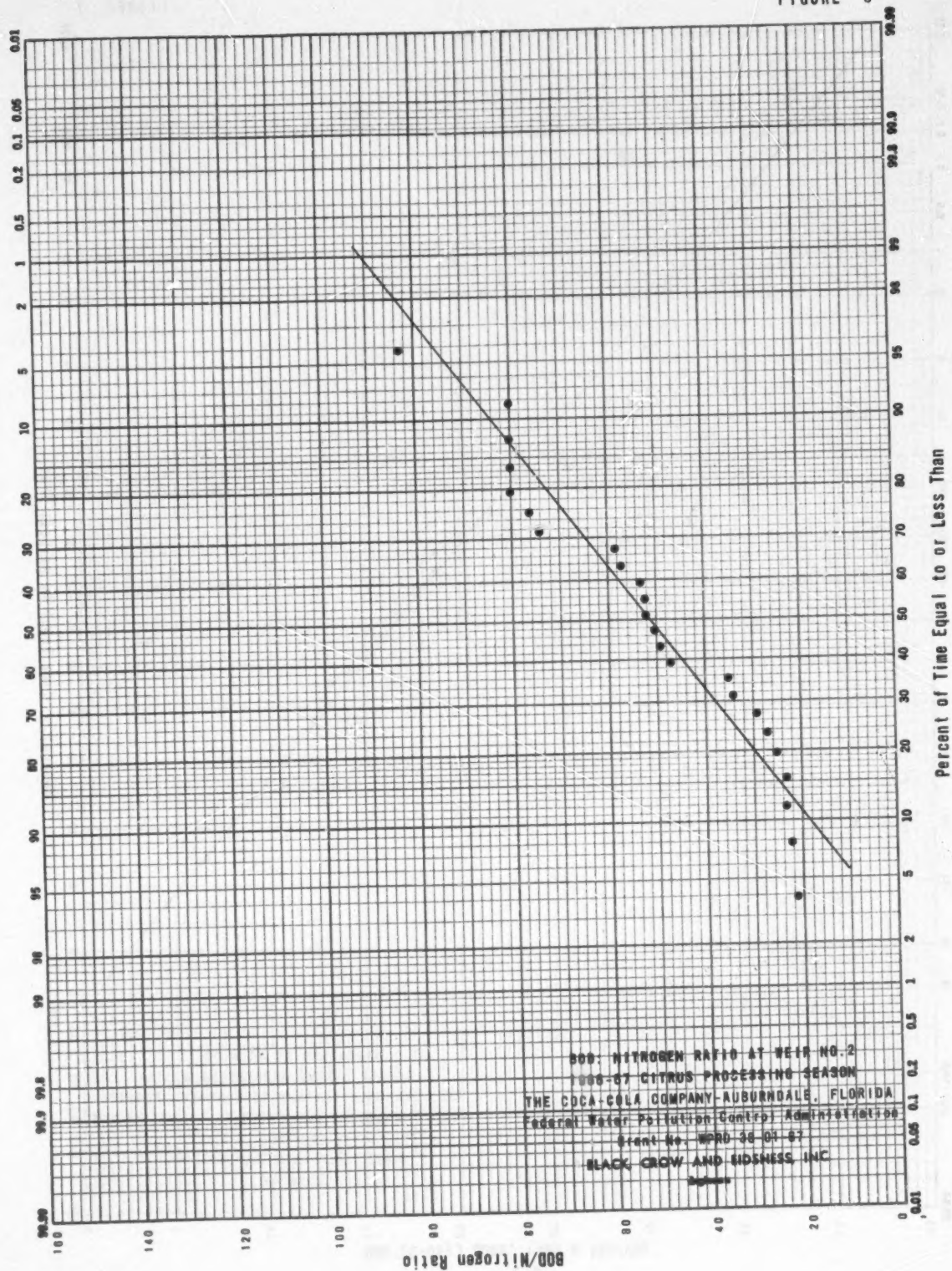


FIGURE 7



0570



000: NITROGEN RATIO AT WEIR NG.2
1986-87 CITRUS PROCESSING SEASON
THE COCA-COLA COMPANY-AUBURNDALE, FLORIDA
Federal Water Pollution Control Administration
Grant No. WPRD 36-03-67
BLACK CROW AND SIDSNESS INC

FIGURE 8

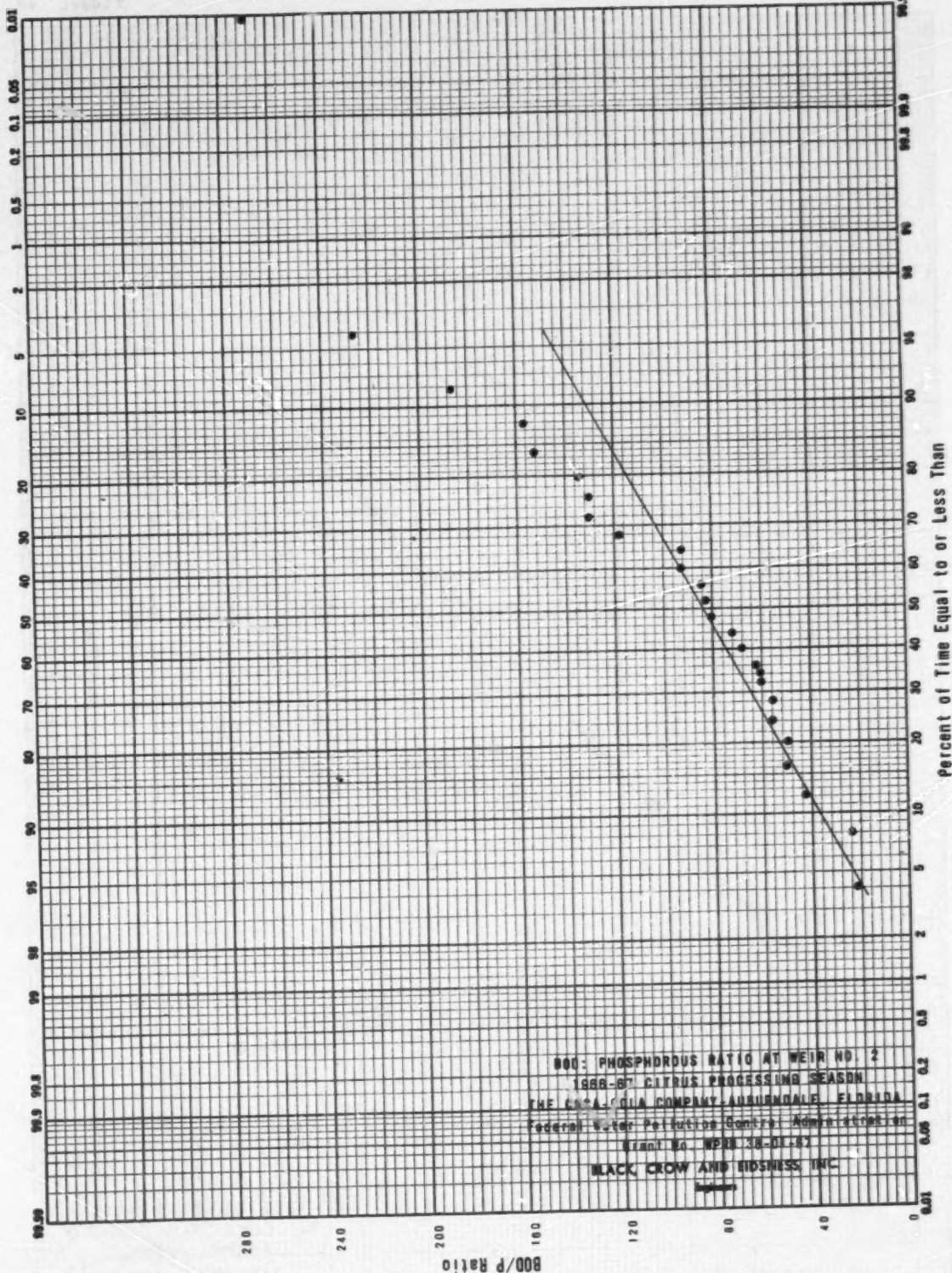


FIGURE 10

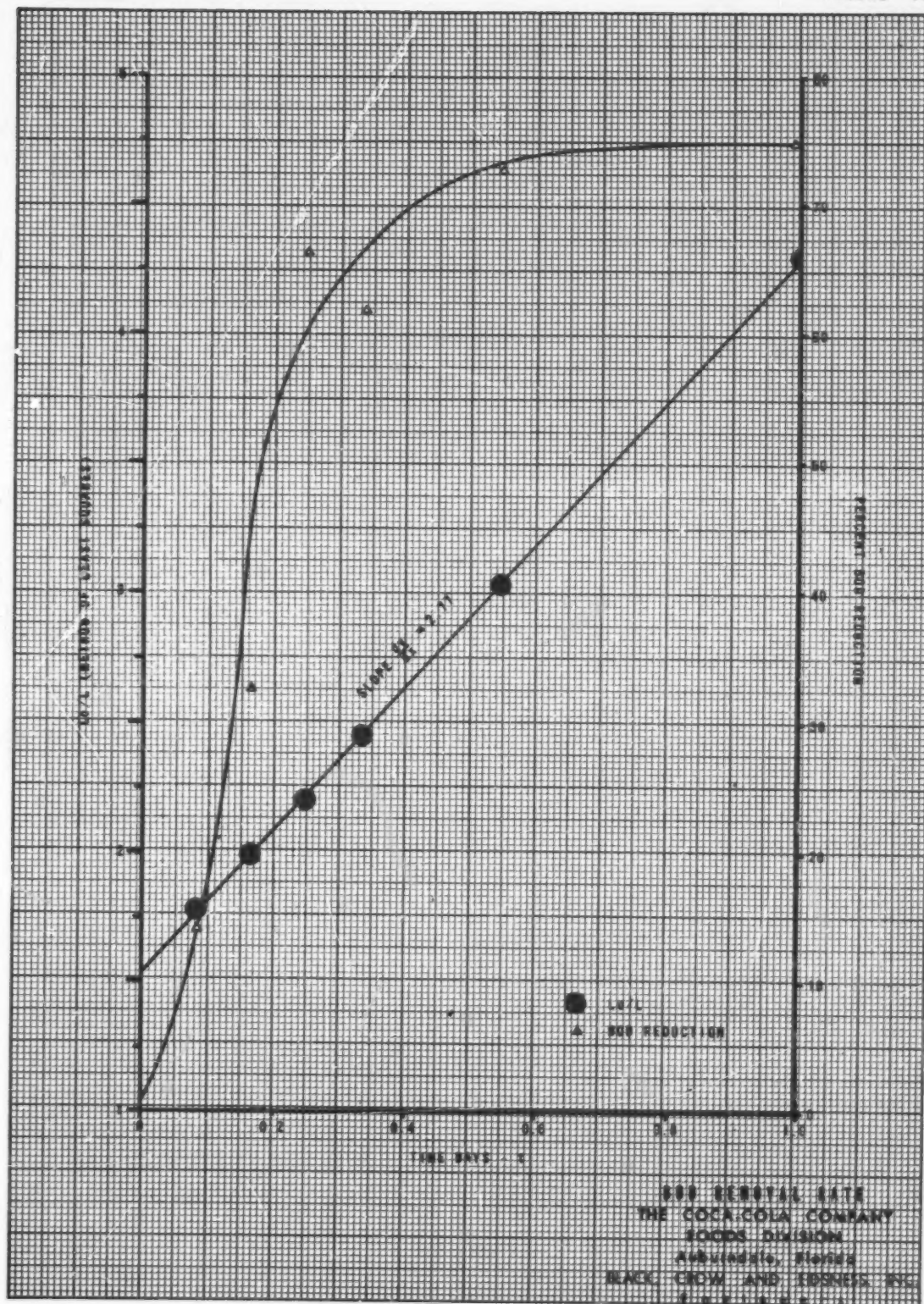


FIGURE 11

DAILY OPERATION RECORD

_____, 19____
WEEKDAY MONTH DAY YEAR

FLOW DATA - NGC (FIGURES IN TEN THOUSANDS OF GALLONS (POND 1) AND THOUSANDS OF GALLONS (RS), AS RECORDED ON TOTALIZERS. READINGS TAKEN AT _____ M., EACH DAY.)

<u>EFFLUENT POND 1</u>	<u>RECIRCULATED SLUDGE</u>	<u>PLANT INFLUENT</u>
PRESENT DAY _____	_____	EFFLUENT POND 1 _____
PREVIOUS DAY _____	_____	RECIRCULATED SLUDGE _____
DIFFERENCE _____	% INFLUENT FLOW _____	FLOW _____

<u>PHOSPHORIC ACID</u>	<u>NUTRIENT FEED</u>	<u>AMMONIA</u>
TIME _____		TIME _____
SETTING (GALS/24 HRS) _____		SETTING (GALS/24 HRS) _____

<u>RAINFALL</u>	<u>WASTE SLUDGE</u>	
INCHES _____		

ROUTINE SAMPLING AND TESTING RESULTS

SAMPLING POINT	TYPE OF SAMPLE	TEMP. °C.	pH	T E S T				SUSPENDED SOLIDS	
				DO mg/l	COD mg/l	BOD mg/l	SETT. SOL. ml/l	TOTAL mg/l	% VOL.
1. PLANT INFLUENT	DAILY COMPOSITE	-	-	-	-	-	-	-	-
2. POND 1 EFFLUENT	DAILY GRAB	-	-	-	-	-	-	-	-
3. POND 2 EFFLUENT	DAILY COMPOSITE	-	-	-	-	-	-	-	-
4. POND 3 EFFLUENT	DAILY GRAB	-	-	-	-	-	-	-	-
5. POND 4 EFFLUENT	DAILY COMPOSITE	-	-	-	-	-	-	-	-
6. RECIRCULATED WASTE	DAILY GRAB	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-
7. PLANT INFLUENT	GRAB	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-
8. POND 1	GRAB	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-
9. ARABS	DAILY COMPOSITE	-	-	-	-	-	-	-	-

REMARKS: _____

OPERATOR

APPENDIX 1

**GRAB SAMPLE ANALYSES TAKEN DURING
JANUARY AND FEBRUARY
INDICATED THE FOLLOWING IN-PLANT FLOWS
AND WASTEWATER STRENGTHS: (1)**

<u>Source</u>	<u>Flow, mgd⁽²⁾</u>	<u>COD, mg/l</u>
The Coca-Cola Company		
Hi-C Plant	2.0	2,750
By-products, including feed mill and molasses evaporator	2.0	640
Concentrate Plant		
Process	3.0	810
Evaporator	7.0	50
Adams Packing Company		
Concentrate Plant (total)	8.4	660
Juice Plant	1.5	830
Sectioning Plant	1.5	280
By-products, including feed mill and molasses evaporator	1.7	430

(1) These are grab samples taken during periods of overload at the wastewater treatment plant and the values are not considered to be typical under all operating conditions.

(2) Estimated flows.

APPENDIX 2

AUBURNDALE - THE COCA-COLA COMPANY FOODS DIVISION

Kinetic Study at 20° C

Lo = 92 mg/l

Air 5 lpm

S.S. = 160 mg/l

Samples filtered through glass wool

Calculated $\Theta = 1.06$

No Nutrients - $k_{20^{\circ}\text{C}} = 2.56$

Hours	t	L	Lo/L Experimental	Lo/L Least Squares
2	.0833	83	1.11	1.33
4	.1666	71	1.29	1.55
6	.2500	44	2.09	1.76
8	.3333	50	1.84	1.97
13	.5420	30	3.07	2.51
24	1.0000	27	3.40	3.68

Let x = Lo/L

Let y = t

Slope $\frac{dy}{dx} = \frac{2.35}{.9167} = 2.56$

	x	y	y ²	xy
1.	1.11	0.0833	0.0069	0.0927
2.	1.29	0.1666	0.0277	0.2149
3.	2.09	0.2500	0.0625	0.5225
4.	1.84	0.3333	0.1111	0.6133
5.	3.07	0.5420	0.2938	1.6639
6.	3.40	1.0000	1.0000	3.4000
Σ	12.80	2.373	1.502	6.5073

$$x_n = m(y) + b$$

$$m = \frac{n \Sigma xy - \Sigma x \Sigma y}{n \Sigma y^2 - (\Sigma y)^2}$$

$$b = \frac{\Sigma y^2 \Sigma x - \Sigma y \Sigma xy}{n \Sigma y^2 - (\Sigma y)^2}$$

$$m = \frac{6(6.5073) - (12.80)(2.375)}{6(1.502) - (2.375)^2} = 2.564$$

$$b = \frac{(1.502)(12.80) - (2.375)(6.5073)}{6(1.502) - (2.375)^2} = 1.119$$

n = number of points

$$x_0 = (2.564)(0) + 1.119 = 1.119$$

$$x_1 = (2.564)(.0833) + 1.119 = 1.333$$

$$x_2 = (2.564)(.1666) + 1.119 = 1.546$$

$$x_3 = (2.564)(.2500) + 1.119 = 1.760$$

$$x_4 = (2.564)(.3333) + 1.119 = 1.967$$

$$x_5 = (2.564)(.5420) + 1.119 = 2.508$$

$$x_6 = (2.564)(1.000) + 1.119 = 3.683$$

AUBURNDALE - THE COCA-COLA COMPANY FOODS DIVISION

Kinetic Study at 20° C

Lo 92 mg/l Air 5 lpm

S.S. = 160 mg/l

Samples filtered through glass wool

Calculated $\Theta = 1.06$ Nutrients - 5 mg/l NH_3 - N + 1 mg/l - PO_4 - P $k_{20^\circ\text{C}} = 2.77$

<u>t</u>	<u>L</u>	<u>Lo/L Experimental</u>	<u>Lo/L Least Squares</u>
.0833	79	1.16	1.76
.1666	62	1.48	1.99
.2500	31	2.97	2.22
.3333	35	2.63	2.45
.5420	25	3.68	3.03
1.0000	24	3.84	4.30

$$\text{Slope } \frac{dy}{dx} = \frac{2.54}{0.9167} = 2.77$$

	<u>x</u>	<u>y</u>	<u>y²</u>	<u>xy</u>
1.	1.16	.0835	.0069	.0969
2.	1.48	.1666	.0277	.2466
3.	2.97	.2500	.0625	.7425
4.	2.64	.3333	.1111	.8766
5.	3.68	.5420	.2938	1.9946
6.	3.84	1.0000	1.0000	3.8400
Σ	= 15.76	2.375	1.502	7.797

$$m = \frac{6(7.797) - (15.760)(2.375)}{6(1.502) - (2.375)^2} = 2.774$$

$$b = \frac{(1.502)(15.760) - (2.375)(7.797)}{6(1.502) - (2.375)^2} = 1.529$$

$$x_0 = (2.774)(0) + 1.529 = 1.529$$

$$x_1 = (2.774)(.0833) + 1.529 = 1.761$$

$$x_2 = (2.774)(.1666) + 1.529 = 1.991$$

$$x_3 = (2.774)(.2500) + 1.529 = 2.223$$

$$x_4 = (2.774)(.3333) + 1.529 = 2.454$$

$$x_5 = (2.774)(.5420) + 1.529 = 3.033$$

$$x_6 = (2.774)(1.000) + 1.529 = 4.303$$

APPENDIX 4

LEESBURG - THE COCA-COLA COMPANY FOODS DIVISION

$$k_{20^{\circ}\text{C}} = 2.86$$

Lo = 121
Temp = 25° C
S.S. = 220 mg/l

t	L	Lo/L Experimental	Lo/L Least Squares
.0833	121	1.00	0.729
.2708	95	1.27	1.413
.3542	81	1.49	1.717
1.0000	29	4.17	4.073

$$\text{Slope } \frac{dy}{dx} = \frac{3.344}{0.9167} = 3.65$$

	x	y	y ²	xy
1.	1.00	.0833	.0069	.0833
2.	1.27	.2708	.0733	.3439
3.	1.49	.3542	.1244	.5278
4.	4.17	1.0000	1.0000	4.1700
Σ =	7.93	1.708	1.206	5.125

$$m = \frac{4(5.125) - (7.93)(1.708)}{4(1.206) - (1.708)^2} = 3.648$$

$$b = \frac{(1.206)(7.93) - (1.708)(5.125)}{4(1.206) - (1.708)^2} = 0.425$$

$$\begin{aligned} x_0 &= 3.648(0) + 0.425 = 0.425 \\ x_1 &= 3.648(.0833) + 0.425 = 0.729 \\ x_2 &= 3.648(.2708) + 0.425 = 1.413 \\ x_3 &= 3.648(.3542) + 0.425 = 1.717 \\ x_4 &= 3.648(1.000) + 0.425 = 4.073 \end{aligned}$$

$$k_t = k_{20^{\circ}\text{C}} \Theta^{T-20}$$

$$k_{20^{\circ}\text{C}} = \frac{3.65}{1.276}$$

$$k_{20^{\circ}\text{C}} = 2.86$$

THEORETICAL CONSIDERATIONS
AERATED LAGOON DESIGN
THE COCA-COLA COMPANY FOODS DIVISION
AUBURNDALE, FLORIDA
(Reference No. 3)

$$\frac{\text{Influent BOD}}{\text{Effluent BOD}} = k_t (\text{Detention Time}) + 1$$

Where k_t = BOD removal rate coefficient

Combined Wastewater Characteristics

Flow, mgd	30
BOD, mg/l	130
BOD, lbs/day	32,500
BOD removal rate coefficient ($k_{20^{\circ}\text{C}}$)	1.46
Temperature coefficient, Θ	1.05
Wastewater temperature, $^{\circ}\text{F}$	91.5
Minimum monthly ambient temperature, $^{\circ}\text{F}$	59.0

1. Pond No. 1 Temperature 25.4°C

$$\begin{aligned} k_t &= k_{20^{\circ}\text{C}} \Theta^{t-20} \\ &= (1.46)(1.05)^{5.4} \end{aligned}$$

$$k_{25.4} = 1.90$$

2. Detention Time (Winter Conditions)

$$\frac{\text{Initial BOD}}{\text{Final BOD}} = k_{25.4}^D + 1$$

$$\frac{130}{12} = 1.90D + 1$$

$$D = 5.2 \text{ days}$$

3. Volume - (Average Pond Depth 12.0 Feet)

$$V = \text{MGD} \times D$$

$$= (30)(5.2)$$

$$= 156 \text{ MMG} = 20.9 \text{ mcf} = 1.74 \text{ mft}^2 = 40A$$

$$T_w = \frac{(30)(91.5) + (12)(1.74)(59)}{30 + (12)(1.74)} = 78.1^\circ\text{F}$$

Compared to 77.7°F from actual plant operation.

4. Oxygen Requirements

$$\text{lbs O}_2/\text{day} = (1.3)(30)(130)(8.34)(.90)$$

$$= 1,584 \text{ pph}$$

5. Oxygen Due to Surface Aeration

$$\text{lbs O}_2/\text{hr/sq ft} = 0.7(7.8 - 2.0) \times 62.4 \times 10^{-6}$$

$$= 253 \times 10^{-6}$$

$$\text{Surface area } 1.74 \times 10^6 \text{ sq ft}$$

$$\text{lbs O}_2/\text{hr} = (253)(1.74)$$

$$= 440$$

6. Oxygen Required from Mechanical Aerators

$$N_m = N_t - N_s$$

$$N_m = \text{O}_2 \text{ from mechanical aerators}$$

$$N_t = \text{Total oxygen required}$$

$$N_s = \text{O}_2 \text{ from surface aeration}$$

$$1,144 = 1,584 - 440$$

7.

H. P. Required - (Assume 12 large units will be sufficient)

$$\frac{1,144}{12} = 95 \text{ lbs O}_2/\text{hr}$$

$$\frac{95 \text{ lbs O}_2/\text{hr}/\text{hp}}{2.5 \text{ lbs O}_2/\text{hr}} = 38 \text{ hp} - \text{Say } 40 \text{ hp}$$

$\therefore$ 12 - 40 hp units required (minimum)

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